

**EPA Superfund
Record of Decision:**

**ABERDEEN PROVING GROUND (EDGEWOOD AREA)
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ABERDEEN PROVING GROUND

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#INTRO

1.0 INTRODUCTION

THE OLD O-FIELD SITE (THE SITE), ALONG WITH THE ENTIRE EDGEWOOD AREA OF ABERDEEN PROVING GROUND (APG), WAS LISTED ON THE NATIONAL PRIORITIES LIST (NPL) PURSUANT TO THE COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION AND LIABILITY ACT, 42 USC S 9601 ET SEQ. (CERCLA) ON FEBRUARY 21, 1990, DUE TO ITS HISTORY OF ON-SITE HAZARDOUS WASTE AND ORDNANCE DISPOSAL. OLD O-FIELD HAS BEEN THE SUBJECT OF NUMEROUS INVESTIGATIONS WHICH IDENTIFIED INORGANIC AND ORGANIC CONTAMINATION IN THE SOILS, GROUNDWATER, AND INTERCONNECTED SURFACE WATER IN THE VICINITY OF THE SITE. THIS INTERIM ACTION RECORD OF DECISION (ROD) ADDRESSES ONLY ONE OPERABLE UNIT (OU ONE) FOR THE SITE WHICH WILL ADDRESS GROUNDWATER CONTAMINATION AT OLD O-FIELD AND THE RELATED EFFECTS ON SURFACE WATER.

A HYDROGEOLOGIC ASSESSMENT (HGA) AND PRELIMINARY RISK ASSESSMENT WERE CONDUCTED TO DEFINE THE NATURE AND EXTENT OF CONTAMINATION IN ALL THE AFFECTED MEDIA, AND ASSOCIATED RISKS TO HUMAN HEALTH AND THE ENVIRONMENT. A FOCUSED FEASIBILITY STUDY (FFS) WAS THEN CONDUCTED TO IDENTIFY POTENTIAL SITE-SPECIFIC GROUNDWATER REMEDIATION ALTERNATIVES. FOLLOWING THE FFS, AQUIFER PUMPING TESTS AND GROUNDWATER TREATABILITY STUDIES WERE PERFORMED TO SELECT A GROUNDWATER REMEDIAL ALTERNATIVE WHICH WAS PRESENTED TO THE PUBLIC IN THE PROPOSED PLAN. THE SELECTED GROUNDWATER REMEDIAL ALTERNATIVE CONSISTS OF A PREFERRED EXTRACTION/DISCHARGE ALTERNATIVE COMBINED WITH A PREFERRED TREATMENT ALTERNATIVE.

THIS ROD SUMMARIZES THE ALTERNATIVE SELECTION PROCESS AND PRESENTS THE SELECTED REMEDY FOR GROUNDWATER CONTAMINATION AT OLD O-FIELD. THE ROLE OF THE PUBLIC IN THE REMEDY SELECTION PROCESS IS ALSO DISCUSSED. THE SELECTED REMEDY IS CONSIDERED AN INTERIM ACTION BECAUSE THE DISPOSED MATERIALS (I.E., THE CONTAMINATION SOURCE) REMAIN AT OLD O-FIELD, AND A REMEDIAL INVESTIGATION (RI), FEASIBILITY STUDY (FS), AND RISK ASSESSMENT ARE NOT COMPLETE AT THIS TIME. A FINAL ROD FOR THE OLD O-FIELD SITE WILL BE ISSUED AT THE CONCLUSION OF THE RI/FS.

1.1 SITE LOCATION AND DESCRIPTION

OLD O-FIELD IS A 4.5-ACRE FENCED HAZARDOUS WASTE AND ORDNANCE DISPOSAL SITE LOCATED ON THE LOWER HALF OF THE GUNPOWDER NECK IN THE EDGEWOOD AREA OF ABERDEEN PROVING GROUND, MARYLAND. AS ILLUSTRATED IN FIGURE 1, THE SITE IS LOCATED IN EASTERN MARYLAND IN CLOSE PROXIMITY TO THE CHESAPEAKE BAY. OLD O-FIELD, AS ILLUSTRATED IN FIGURE 2, IS BORDERED BY SURFACE WATER ON THREE SIDES: WATSON CREEK TO THE NORTH AND EAST, AND THE GUNPOWDER RIVER TO THE WEST. THE GUNPOWDER RIVER MAY BE CONSIDERED PART OF THE CHESAPEAKE BAY ESTUARINE SYSTEM. WATSON CREEK, BETTER DESCRIBED AS A POND, HAS A 2,180-ACRE WATERSHED AND DISCHARGES INTO THE GUNPOWDER RIVER AT A MAN-MADE CULVERT. OLD O-FIELD IS SITUATED ON A LOCAL TOPOGRAPHIC HIGH WITH A 4 TO 6 FOOT RELIEF ACROSS THE FIELD.

ACCESS TO THE SOUTHERN PART OF THE GUNPOWDER NECK, INCLUDING OLD O-FIELD, IS CONTROLLED BY WATSON CREEK ROAD, WHICH RUNS NORTH-SOUTH ALONG THE WEST SIDE OF THE FIELD. THE FIELD IS LOCATED WITHIN A SECURE SECTION OF THE EDGEWOOD AREA WHERE ACCESS IS RESTRICTED AND ENTRY IS GRANTED ONLY AFTER CREDENTIALS HAVE BEEN CHECKED BY A SECURITY GUARD. IN ADDITION, THE AREA IS PATROLLED ROUTINELY BY GUARDS IN VEHICLES AND BOATS. THE FIELD IS

SURROUNDED BY A CHAIN-LINK/BARBEDWIRE FENCE WITH HAZARDOUS WASTE AND TOXIC CHEMICAL AGENT WARNING SIGNS. THE SITE IS MOSTLY OVERGROWN WITH SCRUB VEGETATION AND SMALL TREES, WITH SEVERAL PARTIALLY OPEN DISPOSAL PITS VISIBLE WITHIN THE FENCED AREA.

THE MAJORITY OF THE LAND SURROUNDING OLD O-FIELD IS CURRENTLY BEING USED AS TESTING RANGES. TEST OPERATIONS SOUTH OF THE FIELD INCLUDE THOSE OF THE COMBAT SYSTEMS TEST ACTIVITY, (CSTA) WHICH IS A MAJOR MISSION OF THE US ARMY TEST AND EVALUATION COMMAND. WITHIN ARMY PROPERTY, 3.5 MILES NORTH OF THE FIELD, IS THE INDUSTRIAL SECTOR OF EDGEWOOD AREA, WHICH INCLUDES THE CHEMICAL RESEARCH, DEVELOPMENT AND ENGINEERING CENTER AS WELL AS A NUMBER OF OFFICE BUILDINGS. EDGEWOOD AREA ALSO INCLUDES A NUMBER OF TROOP BARRACKS AND AN ON-POST FAMILY HOUSING AREA CONTAINING APPROXIMATELY 1700 RESIDENTS. THE TOWN OF EDGEWOOD (POPULATION APPROXIMATELY 20,000) IS LOCATED WITHIN 5 MILES OF THE FIELD. THE CLOSEST OFF-POST HOUSING DEVELOPMENT IS LOCATED IN GRACES QUARTERS WHICH IS APPROXIMATELY 2.5 MILES DUE WEST OF THE FIELD ACROSS THE GUNPOWDER RIVER.

1.2 SITE HISTORY AND ENFORCEMENT ACTIVITIES

DURING THE 1940S AND EARLY 1950S, 35 UNLINED PITS AND TRENCHES WERE DUG WITHIN OLD O-FIELD AND USED FOR THE DISPOSAL OF CHEMICAL-WARFARE AGENTS (E.G., MUSTARD, LEWISITE, ADAMSITE, WHITE PHOSPHORUS), MUNITIONS, CONTAMINATED EQUIPMENT, AND MISCELLANEOUS HAZARDOUS WASTE. THE MAXIMUM DEPTH OF THE TRENCHES IS AT LEAST 12 FEET, AND ALMOST ALL OF THE TRENCHES ARE COVERED WITH SOIL. THE PRESENCE OF CHEMICAL-AGENT WASTES, MUNITIONS, AND OTHER HAZARDOUS MATERIALS WITHIN THE LANDFILL HAS IMPACTED THE GROUNDWATER AT OLD O-FIELD AND THE INTERCONNECTING SURFACE WATER IN WATSON CREEK.

SEVERAL DECONTAMINATION AND CLEANUP OPERATIONS HAVE BEEN PERFORMED AT OLD O-FIELD BEGINNING WITH SURFACE SWEEPS AND DEMILITARIZATION EFFORTS IN 1949 AND CONTINUING THROUGH THE EARLY 1970S. THE MOST NOTABLE OF THESE WAS A CLEANUP OPERATION CARRIED OUT IN DECEMBER 1949 WHICH INVOLVED APPLICATION OF 1,000 BARRELS OF DECONTAMINATING AGENT NON-CORROSIVE (DANC) TO THE FIELD IN AN ATTEMPT TO DETOXYFY MUSTARD THAT HAD BEEN SCATTERED OVER THE AREA BY SEVERAL SPONTANEOUS DETONATIONS. DANC CONTAINS 5 PERCENT 1,3-DICHLORO-5,5-DIMETHYLHYDANTOIN (THE ACTIVE DECONTAMINATING AGENT) IN 95 PERCENT 1,1,2,2-TETRACHLOROETHANE. TETRACHLOROETHANE AND ITS DEGRADATION PRODUCTS HAVE BEEN IDENTIFIED AT ELEVATED LEVELS IN GROUNDWATER AT OLD O-FIELD; THUS, IT APPEARS LIKELY THAT THIS EFFORT DIRECTED AT CHEMICAL-WARFARE AGENT DECONTAMINATION ACTUALLY RESULTED IN GROUNDWATER CONTAMINATION WITH CHLORINATED HYDROCARBON COMPOUNDS.

ANOTHER MAJOR CLEANUP EFFORT WAS UNDERTAKEN IN 1953 WHEN THE FIELD WAS SOAKED WITH HUNDREDS OF GALLONS OF FUEL OIL, IGNITED, AND ALLOWED TO BURN FOR DAYS. LIME (CALCIUM HYDROXIDE) WAS DISPERSED ONTO SURROUNDING TREES THROUGH THE USE OF 2,4,6-TRINITROTOLUENE (TNT) IN RESPONSE TO EXPLOSIONS THAT SCATTERED MUSTARD THROUGHOUT THE AREA AND INTO WATSON CREEK AND THE GUNPOWDER RIVER. OTHER DECONTAMINATION EFFORTS INVOLVED THE USE OF SUPERTROPICAL BLEACH (A CALCIUM HYPOCHLORITE/CALCIUM HYDROXIDE MIXTURE), LIME, AND SODIUM HYDROXIDE TO DESTROY CHEMICAL AGENTS AT THE FIELD. FOLLOWING THIS OPERATION, FURTHER DECONTAMINATION AND CLEANUP EFFORTS WERE LIMITED TO REMOVING AND SECURING ORDNANCE ITEMS RECOVERED IN SURFACE SWEEPS OF THE FIELD; THE LAST SURFACE SWEEP ACTIVITY WAS REPORTEDLY PERFORMED IN THE MID-1970S. NO DISPOSAL OF MUNITIONS OR HAZARDOUS WASTE APPEARS TO HAVE BEEN PERFORMED AFTER 1953.

THE OLD O-FIELD SITE, LIKE MUCH OF THE GUNPOWDER NECK AREA, WAS MIXED FARMLAND AND WOODLAND PRIOR TO ITS PURCHASE BY THE US ARMY IN 1917 FOR THE FORMATION OF EDGEWOOD ARSENAL. HISTORICAL AERIAL PHOTOGRAPHS INDICATE SOME CLEARED AREAS AT THE FIELD IN 1929, BUT SHOW NO EVIDENCE OF DISPOSAL ACTIVITIES. THE AERIAL PHOTOGRAPHIC RECORD SUPPORTS HISTORICAL DATA THAT SUGGEST THAT THE MAJOR PERIOD OF DISPOSAL OPERATIONS AT THE FIELD WAS 1941 TO 1952 WITH LITTLE SUBSEQUENT ACTIVITY.

THE EDGEWOOD AREA, INCLUDING OLD O-FIELD, WAS LISTED ON THE NPL ON FEBRUARY 21, 1990. THE US ARMY CONDUCTED SEVERAL INVESTIGATIONS OF OLD O-FIELD INCLUDING THE HGA, FFSS FOR GROUNDWATER REMEDIATION AND SOURCE CONTROL, THE PRELIMINARY RISK ASSESSMENT, AQUIFER PUMPING TESTS, AND GROUNDWATER TREATABILITY STUDIES TO IDENTIFY THE TYPES, QUANTITIES, AND LOCATIONS OF CONTAMINANTS; AND TO DEVELOP AND EVALUATE METHODS FOR ADDRESSING CONTAMINATION PROBLEMS AT THE SITE. THESE STUDIES HAVE PROVIDED THE FOLLOWING CHARACTERIZATION DATA REGARDING CHEMICAL CONTAMINATION AT OLD O-FIELD:

* ON-SITE SOILS IN THE LANDFILL AREA APPEAR TO BE

CONTAMINATED WITH UNKNOWN AMOUNTS OF CHEMICAL-WARFARE AGENTS, MUNITIONS, DECONTAMINATING AGENTS, AND OTHER HAZARDOUS SUBSTANCES;

- * A PLUME OF CONTAMINATED GROUNDWATER EXTENDS EAST/NORTHEAST FROM THE LANDFILL TO WATSON CREEK IN TWO AQUIFERS (THE WATER-TABLE AQUIFER AND THE UPPER CONFINED AQUIFER);
- * THE CONTAMINATED GROUNDWATER PLUME CONTAINS CHEMICAL-WARFARE AGENT DEGRADATION PRODUCTS, INCLUDING THIODIGLYCOL AND 1,4-DITHIANE (DEGRADATION PRODUCTS OF MUSTARD); VARIOUS METALS INCLUDING ARSENIC, IRON, ANTIMONY, AND ZINC; CHLORINATED ALIPHATIC HYDROCARBONS INCLUDING 1,1,2,2-TETRACHLOROETHANE CHLOROFORM, TETRACHLOROETHYLENE, TRICHLOROETHYLENE, VINYL CHLORIDE, AND METHYLENE CHLORIDE; AROMATIC AND NITROAROMATIC COMPOUNDS INCLUDING BENZENE, CHLOROBENZENE, AND NITROBENZENE; ORGANOPHOSPHORUS COMPOUNDS, INCLUDING DIISOPROPYLMETHYLPHOSPHONATE (DIMP), FROM THE DEGRADATION OF NERVE AGENT COMPOUNDS (E.G., GB); AND (POSSIBLY) ORGANOARSENIC COMPOUNDS FROM DISPOSAL OF ARSENICALS (E.G., LEWISITE AND ADAMSITE); AND
- * SURFACE WATER AND SEDIMENTS IN WATSON CREEK CONTAIN ARSENIC, MERCURY, TRANSITION METALS, CHLORINATED ALIPHATIC HYDROCARBONS, AROMATIC HYDROCARBONS, AND A VARIETY OF ORGANIC COMPOUNDS WHICH MAY BE RELATED TO ACTIVITIES AT OLD O-FIELD.

SOME OF THE CHLORINATED ALIPHATIC HYDROCARBONS AND AROMATIC HYDROCARBONS ARE LIKELY PRESENT DUE TO DECONTAMINATION EFFORTS AT THE SITE WHICH UTILIZED DANC AND FUEL OIL, AS WELL AS FROM CHEMICAL AGENT MIXTURES THAT UTILIZED THESE COMPOUNDS (E.G., CNC, CNB). IN ADDITION, THESE SUBSTANCES MAY BE PRESENT AS THE RESULT OF CHEMICAL AND/OR BIOLOGICAL DEGRADATION, AND FROM REACTIONS BETWEEN WASTE COMPOUNDS AND DECONTAMINATING AGENTS.

BECAUSE OF THE ENVIRONMENTAL IMPACTS ASSOCIATED WITH OLD O-FIELD IN CONJUNCTION WITH OTHER AREAS OF APG, AN INTERAGENCY AGREEMENT (THE AGREEMENT) WAS ESTABLISHED IN MARCH, 1990, UNDER SECTION 120 OF CERCLA BETWEEN THE US ENVIRONMENTAL PROTECTION AGENCY, REGION III, AND THE US DEPARTMENT OF THE ARMY, ABERDEEN PROVING GROUND. THE PURPOSE OF THE AGREEMENT WAS TO ESTABLISH A PROCEDURAL FRAMEWORK AND SCHEDULE FOR DEVELOPING, IMPLEMENTING, AND MONITORING APPROPRIATE RESPONSE ACTIONS AT APG SITES IN ACCORDANCE WITH CERCLA, THE RESOURCE CONSERVATION AND RECOVERY ACT (RCRA), THE NATIONAL OIL AND HAZARDOUS SUBSTANCES POLLUTION CONTINGENCY PLAN (NCP), AND OTHER APPLICABLE FEDERAL AND STATE REGULATIONS. INITIAL HGA STUDIES OF OLD O-FIELD WERE CONDUCTED AS A REQUIREMENT OF A RCRA CORRECTIVE ACTION PERMIT ISSUED TO THE ARMY. PURSUANT TO THE AGREEMENT, THE ARMY AGREED TO CONTINUE THE STUDIES IN ACCORDANCE WITH CERCLA. ALL PHASES OF REMEDIATION FOR OLD O-FIELD ARE COVERED UNDER THE AGREEMENT INCLUDING INVESTIGATION, DEVELOPMENT, SELECTION, AND IMPLEMENTATION OF RESPONSE ACTIONS.

1.3 SCOPE AND ROLE OF OPERABLE UNIT/RESPONSE ACTION WITHIN SITE STRATEGY

THE PROBLEMS AT THE OLD O-FIELD SITE ARE TECHNOLOGICALLY COMPLEX. AS A RESULT, THE US ARMY HAS DIVIDED THE REMEDIATION INTO THREE MANAGEABLE COMPONENTS CALLED "OPERABLE UNITS (OUS)." AN OPERABLE UNIT IS DEFINED IN THE NATIONAL OIL AND HAZARDOUS SUBSTANCES POLLUTION CONTINGENCY PLAN, 40 CFR 300, (NCP) AS A DISCRETE ACTION THAT COMPRISES AN INCREMENTAL STEP TOWARDS COMPREHENSIVELY ADDRESSING SITE PROBLEMS. THIS DISCRETE PORTION OF A REMEDIAL RESPONSE MANAGES MIGRATION, OR ELIMINATES OR MITIGATES A RELEASE, THREAT OF RELEASE, OR PATHWAY OF EXPOSURE. THE OUS FOR OLD O-FIELD ARE AS FOLLOWS:

OLD O-FIELD OU ONE: CONTAMINATION OF THE GROUNDWATER AQUIFERS.

OLD O-FIELD OU TWO: CONTAMINATION OF THE SOILS AND THE PRESENCE
 OF CHEMICAL-WARFARE AGENTS AND MUNITIONS IN
 THE LANDFILL (I.E., THE SOURCE).

OLD O-FIELD OU THREE: CONTAMINATION OF WATSON CREEK.

THIS ROD ADDRESSES THE FIRST OPERABLE UNIT (OU ONE) WHICH DEALS WITH THE CONTAINMENT OF CONTAMINATED GROUNDWATER AT OLD O-FIELD. THE CONTAMINATED GROUNDWATER DISCHARGES DIRECTLY TO WATSON CREEK AND INDIRECTLY, VIA WATSON CREEK, TO THE GUNPOWDER RIVER. BOTH WATSON CREEK AND THE GUNPOWDER RIVER ARE PART OF THE SENSITIVE UPPER CHESAPEAKE BAY ESTUARINE SYSTEM. THE CONTAMINATED GROUNDWATER POSES ENVIRONMENTAL RISKS TO SENSITIVE AQUATIC AND TERRESTRIAL ECOSYSTEMS IN WATSON CREEK, THE GUNPOWDER RIVER, AND THE SURROUNDING WETLANDS. THE PURPOSES OF THE OU ONE RESPONSE ACTION ARE TO CONTAIN THE GROUNDWATER CONTAMINATION TO PREVENT FURTHER DISCHARGE OF CONTAMINANTS INTO WATSON CREEK AND MITIGATE ASSOCIATED ENVIRONMENTAL IMPACTS, AND TO PROVIDE TREATMENT OF THE EXTRACTED GROUNDWATER PRIOR TO DISCHARGE.

CONTAINMENT OF THE CONTAMINATED GROUNDWATER HAS BEEN IDENTIFIED AS AN INTERIM ACTION FOR THE OLD O-FIELD SITE. EXTRACTION OF THE GROUNDWATER FOR SUBSEQUENT TREATMENT WILL NOT CLEAN UP THE AQUIFERS SINCE THE SOURCE OF THE CONTAMINATION (OU TWO) IS STILL PRESENT. ACCELERATED INTERIM ACTION FOR THE GROUNDWATER (OU ONE) IS REQUIRED TO PREVENT FURTHER DAMAGE TO WATSON CREEK (OU THREE).

THE US ARMY HAS NOT YET MADE ANY DECISIONS CONCERNING THE TYPES OF ACTIONS WHICH MAY BE TAKEN TO ADDRESS OUS TWO AND THREE. THE EXISTENCE OF DISPOSED CHEMICAL-WARFARE AGENTS, MUNITIONS, AND OTHER HAZARDOUS SUBSTANCES IN THE LANDFILL IS A DIFFICULT PROBLEM TO ADDRESS AT THIS SITE BECAUSE OF THE POTENTIAL FOR DIRECT CONTACT WITH THE DISPOSED MATERIALS AND THE CONTINUING CONTAMINATION OF THE SOIL AND GROUNDWATER FROM THE SOURCE. ACTIVE REMEDIATION OF THE SOURCE IS LIKELY TO BE HIGHLY HAZARDOUS AND EXPENSIVE. POTENTIAL ALTERNATIVES IDENTIFIED FOR ACTIVE REMEDIATION OF THE SOURCE AREA (OU TWO) THAT CAN PROVIDE SOURCE REMOVAL, IN-PLACE DESTRUCTION, OR PERMANENT ISOLATION CREATE POTENTIALLY SEVERE HEALTH-AND-SAFETY AND LOGISTICAL PROBLEMS, AND ARE LIKELY TO REQUIRE EXTENSIVE RESEARCH AND DEVELOPMENT EFFORTS AS WELL AS VERY LONG TIME PERIODS FOR IMPLEMENTATION. THE ARMY WILL CONTINUE TO EVALUATE NEW TECHNOLOGIES FOR REMEDIATING THE SOURCE OF THE CONTAMINATION, INCLUDING THE PERFORMANCE OF A COMPREHENSIVE REMEDIAL INVESTIGATION/FEASIBILITY STUDY (RI/FS) OF THE ENTIRE O-FIELD AREA.

1.4 COMMUNITY PARTICIPATION

THE PROPOSED PLAN FOR THE INTERIM ACTION FOR OU ONE AT THE OLD O-FIELD SITE WAS RELEASED TO THE PUBLIC IN JULY, 1991. THE HGA, FFS, AQUIFER TESTING REPORT, AND THE GROUNDWATER TREATABILITY STUDY REPORT ALSO WERE MADE AVAILABLE TO THE PUBLIC ON JULY 3, 1991, IN THE ADMINISTRATIVE RECORD FILE LOCATED AT THE ABERDEEN AND EDGEWOOD BRANCHES OF THE HARFORD COUNTY LIBRARY. IN ADDITION, A PUBLIC MEETING WAS HELD IN THE ABERDEEN PROVING GROUND EDGEWOOD AREA CONFERENCE CENTER ON JULY 25, 1991. AT THIS MEETING, REPRESENTATIVES OF US ENVIRONMENTAL PROTECTION AGENCY (EPA), THE MARYLAND DEPARTMENT OF THE ENVIRONMENT (MDE), AND THE US ARMY ABERDEEN PROVING GROUND (APG) DISCUSSED WITH THE PUBLIC THE PREFERRED REMEDY, AS WELL AS ALL REMEDIAL ALTERNATIVES UNDER CONSIDERATION. A PUBLIC COMMENT PERIOD WAS HELD FROM JULY 3, 1991 THROUGH AUGUST 17, 1991.

A TRANSCRIPT OF THE PUBLIC MEETING IS PROVIDED IN THE RESPONSIVENESS SUMMARY (APPENDIX A) WHICH IS PART OF THIS RECORD OF DECISION, INCLUDING AGENCY RESPONSES TO QUESTIONS POSED BY THE PUBLIC ATTENDEES. ADDITIONAL PUBLIC COMMENTS ARE ALSO ADDRESSED IN THE RESPONSIVENESS SUMMARY. THIS DECISION DOCUMENT PRESENTS THE SELECTED REMEDIAL ACTION FOR OU ONE FOR THE OLD O-FIELD SITE, AS DISCUSSED IN THE PROPOSED PLAN, PUBLIC MEETING AND RESPONSIVENESS SUMMARY.

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2.0 SITE CHARACTERISTICS

THIS SECTION PROVIDES AN OVERVIEW OF OLD O-FIELD CHARACTERISTICS RELATED TO OU ONE INCLUDING RELEVANT HYDROGEOLOGIC DESCRIPTIONS, A SUMMARY OF THE NATURE AND EXTENT OF GROUNDWATER AND SURFACE WATER CONTAMINATION, POTENTIAL ROUTES OF CONTAMINANT MIGRATION AND EXPOSURE, AND A SUMMARY OF HUMAN HEALTH AND ECOLOGICAL RISKS. REMEDIAL ALTERNATIVES, PRESENTED IN SECTION 3.0, WERE DEVELOPED TO ADDRESS THE CONDITIONS

AT OLD O-FIELD DESCRIBED BELOW.

2.1 HYDROGEOLOGIC SETTING

THE HYDROGEOLOGIC SETTING AT OLD O-FIELD OF RELEVANCE TO THIS INTERIM ACTION CONSISTS OF A TWO-AQUIFER SYSTEM (WATER-TABLE AND UPPER CONFINED AQUIFERS), EACH APPROXIMATELY 10 TO 15 FEET THICK, AND SEPARATED BY A THIN, Laterally discontinuous clay confining bed. The hydrogeological cross-section is provided in Figure 3 for section A-A' identified on Figure 4. The water-table aquifer lies 9-15 feet below the ground surface; during the rainy winter months, the groundwater level rises above the bottom of the disposal trenches, which have been excavated to a depth of 12 feet. The presence of contamination in the upper confined aquifer indicates that the confining bed between the water-table aquifer and the upper confined aquifer is discontinuous beneath old o-field, or the trenches may have been excavated through the confining bed. Deeper aquifers that exist at the site are believed to be uncontaminated based on current information.

THE WATER-TABLE AND UPPER CONFINED AQUIFERS ARE RECHARGED BY GROUNDWATER FLOWING FROM THE SOUTHERN PORTION OF GUNPOWDER NECK (E.G., H-FIELD) AND BY VERTICAL INFILTRATION OF PRECIPITATION WITHIN THE OLD O-FIELD AREA. A GROUNDWATER DIVIDE IN BOTH AQUIFERS IS LOCATED APPROXIMATELY 300 FEET WEST OF OLD O-FIELD; GROUNDWATER ALONG THE WESTERN SIDE OF THIS DIVIDE DISCHARGES TO THE GUNPOWDER RIVER, WHEREAS GROUNDWATER ALONG THE EASTERN PORTION OF THE DIVIDE FLOWS BENEATH THE OLD O-FIELD LANDFILL AND DISCHARGES TO WATSON CREEK. Thus, this divide is very important in controlling the distribution of groundwater contamination at the site in that it separates the contaminated plume area in both the water-table and upper-confined aquifers from uncontaminated groundwater flowing northward to discharge into the Gunpowder River. Groundwater flow in the aquifers beneath old o-field is made additionally complex because of tidal effects from the Gunpowder River and Watson Creeks, including lagging and missing tidal cycles in Watson Creek, which are created by the culvert at the creek mouth.

2.2 CONTAMINATION ASSESSMENT SUMMARY

CHEMICALS IDENTIFIED IN THE GROUNDWATER AND INTERCONNECTED SURFACE WATER ARE BASED ON THE UNITED STATES GEOLOGICAL SURVEY (USGS) HYDROLOGIC FIELD INVESTIGATION (1988, 1989). DATA WERE COLLECTED FROM EXISTING MONITORING WELLS LOCATED AROUND THE FIELD AS ILLUSTRATED IN FIGURE 4.

THE GROUNDWATER AT OLD O-FIELD CONTAINS BOTH INORGANIC AND ORGANIC CONTAMINANTS. INORGANIC CONTAMINANTS INCLUDE ANTIMONY, ARSENIC, BORON, CALCIUM, IRON, MAGNESIUM, MANGANESE, POTASSIUM, SODIUM, AND ZINC. DOMINANT ORGANIC CONTAMINANTS ARE: 1) CHLORINATED ALIPHATIC HYDROCARBONS INCLUDING 1,1,2,2 TETRACHLOROETHANE, CHLOROFORM, TETRACHLOROETHYLENE, TRICHLOROETHYLENE, VINYL CHLORIDE, AND METHYLENE CHLORIDE; 2) AROMATIC AND NITROAROMATIC COMPOUNDS INCLUDING BENZENE, CHLOROBENZENE, AND NITROBENZENE; AND 3) CHEMICAL-WARFARE AGENT DEGRADATION PRODUCTS WHICH CONTAIN SULFUR AND PHOSPHORUS INCLUDING THIODIGLYCOL, 1,4-DITHIANE, AND DIMP. A COMPARISON OF MAXIMUM GROUNDWATER CONCENTRATIONS DETECTED FOR SELECTED CHEMICALS WITH AMBIENT WATER QUALITY CRITERIA (AWQC) AND MAXIMUM CONTAMINANT LEVELS (MCLS) IS PRESENTED IN TABLE 1.

MAJOR AREAS OF CONTAMINATION ARE NORTHEAST AND EAST OF OLD O-FIELD. NO SIGNIFICANT CONTAMINATION WAS FOUND IN THE WELL ADJACENT TO THE DISPOSAL PIT WEST OF OLD O-FIELD. THE ESTIMATED OVERALL GROUNDWATER CONTAMINANT PLUME IS ILLUSTRATED IN FIGURE 5. BOTH THE WATER-TABLE AND UPPER CONFINED AQUIFER CONTAIN GROUNDWATER CONTAMINATION. IN GENERAL, THE HIGHEST CONCENTRATIONS ARE MEASURED IN THE WATER-TABLE AQUIFER, ALTHOUGH HIGHER CONCENTRATIONS OF BORON AND 1,1,2,2-TETRACHLOROETHANE ARE PRESENT IN THE UPPER CONFINED AQUIFER THAN IN THE WATER-TABLE AQUIFER.

THE SURFACE WATER OF WATSON CREEK CONTAINS DISSOLVED CONSTITUENTS INCLUDING ARSENIC, MERCURY, TRANSITION METALS, CHLORINATED ALIPHATIC HYDROCARBONS, AND AROMATIC HYDROCARBONS WHICH MAY BE RELATED TO ACTIVITIES AT OLD O-FIELD. A COMPARISON OF MAXIMUM CONCENTRATIONS FOR SELECTED CHEMICALS DETECTED IN SURFACE WATER WITH AWQC AND MCLS IS PRESENTED IN TABLE 2. THE BOTTOM SEDIMENTS IN WATSON CREEK CONTAIN ARSENIC, MERCURY, TRANSITION METALS, POLYNUCLEAR AROMATIC HYDROCARBONS, PHTHALATES, AND OTHER ORGANIC COMPOUNDS. A COMPARISON OF MAXIMUM CONCENTRATIONS FOR SELECTED CHEMICALS DETECTED IN BOTTOM SEDIMENTS WITH AWQC AND MCLS IS PRESENTED IN TABLE 3.

2.3 RISK ASSESSMENT SUMMARY

THERE IS A LIMITED DATA SET AVAILABLE FOR USE IN DETERMINING RISKS POSED BY OU ONE, RESULTING IN CONSIDERABLE UNCERTAINTIES IN COMPUTED HUMAN HEALTH RISKS. HOWEVER, A PRELIMINARY RISK ASSESSMENT WAS PERFORMED FOR OLD O-FIELD DURING 1990 FOR THE PURPOSE OF ESTIMATING HUMAN HEALTH AND/OR ENVIRONMENTAL PROBLEMS THAT COULD RESULT IF REMEDIATION WERE NOT PERFORMED. THIS ANALYSIS WAS CONDUCTED IN CONFORMANCE WITH CURRENT EPA GUIDANCE REGARDING RISK ASSESSMENTS FOR CERCLA SITES USING EXISTING DATA ON CHEMICAL CONDITIONS, AND GROUNDWATER AND SURFACE WATER HYDROLOGY AT THE SITE GATHERED DURING THE HGA AND OTHER STUDIES. THE ASSESSMENT INCLUDED A PRELIMINARY HUMAN HEALTH EVALUATION AS WELL AS A DETAILED ECOLOGICAL ASSESSMENT TO DETERMINE POTENTIAL IMPACTS TO AQUATIC AND TERRESTRIAL SPECIES IN WATSON CREEK AND NEARBY WETLANDS. THIS SUMMARY DISCUSSES ONLY THOSE RISKS ASSOCIATED WITH OU ONE (I.E., CONTAMINATED GROUNDWATER AND INTERCONNECTED SURFACE WATER).

THE USGS HYDROGEOLOGIC FIELD INVESTIGATION (1988, 1989) WAS THE PRIMARY SOURCE OF SAMPLING DATA CONSIDERED IN THE PRELIMINARY RISK ASSESSMENT. SAMPLING DATA WERE AVAILABLE FOR SUBSURFACE SOIL, GROUNDWATER, SURFACE WATER, AND SEDIMENT FOR THE OLD O-FIELD SITE. CHEMICAL ANALYSES WERE LIMITED PRIMARILY TO VOLATILE, SEMIVOLATILE, AND INORGANIC CHEMICAL ANALYSES, ALTHOUGH SELECTED GROUNDWATER SAMPLES WERE ANALYZED FOR AGENT-AND EXPLOSIVE-RELATED COMPOUNDS, HERBICIDES, AND RADIONUCLIDES. BASED ON SAMPLING RESULTS, VOLATILE ORGANIC CHEMICALS AND INORGANIC CHEMICALS (PRINCIPALLY METALS) ARE THE PRIMARY CHEMICALS OF CONCERN IN GROUNDWATER AND SURFACE WATER; WHEREAS POLYNUCLEAR AROMATIC HYDROCARBONS, PHTHALATES, AND METALS ARE THE PRINCIPAL CHEMICALS OF CONCERN IN SEDIMENT. ALSO, AGENT DEGRADATION PRODUCTS AND EXPLOSIVE-RELATED COMPOUNDS ARE OF CONCERN IN GROUNDWATER WHICH WAS THE ONLY MEDIUM SAMPLED FOR THESE COMPOUNDS.

2.3.1 HUMAN HEALTH RISK ASSESSMENT SUMMARY

NO HUMAN RECEPTORS ARE BEING EXPOSED DIRECTLY TO GROUNDWATER AT THIS OU UNDER CURRENT CONDITIONS; RATHER, THE GROUNDWATER ACTS AS A TRANSPORT MEDIUM FOR CONTAMINATION FROM OU ONE TO OU THREE. ADDITIONALLY, THE ARMY BELIEVES IT IS NOT PRACTICAL TO ESTIMATE HUMAN HEALTH RISKS QUANTITATIVELY FOR A FUTURE-USE SCENARIO, BECAUSE OF THE EXISTING INSTITUTIONAL CONTROLS AND NO APPARENT FUTURE USES OF THE SHALLOW GROUNDWATER DUE TO ELEVATED LEVELS OF NATURAL CONSTITUENTS SUCH AS IRON AND CHLORIDES. THEREFORE, THE PRELIMINARY RISK ASSESSMENT FOCUSED ON DETERMINING THE HUMAN HEALTH RISKS POSED BY DISCHARGE OF CONTAMINATED GROUNDWATER INTO WATSON CREEK.

ACCESS TO OLD O-FIELD IS HEAVILY RESTRICTED. THE ONLY CURRENT LAND USE OF OLD O-FIELD IS COMPRISED OF ENVIRONMENTAL SAMPLING AND APG WORKERS DRIVING PAST OLD O-FIELD SEVERAL TIMES A DAY TO GET TO THEIR WORK AREAS. FUTURE LAND USE IS NOT LIKELY TO CHANGE FROM CURRENT LAND USE. THE PRIMARY PATHWAYS BY WHICH HUMAN POPULATIONS COULD BE EXPOSED TO CONTAMINATED GROUNDWATER UNDER CURRENT LAND-USE CONDITIONS ARE CHRONIC EXPOSURE VIA INHALATION OF CHEMICALS THAT HAVE VOLATILIZED FROM WATSON CREEK, AND DERMAL CONTACT AND INCIDENTAL INGESTION OF CHEMICALS DISCHARGED FROM OU ONE INTO SURFACE WATER AND MADE AVAILABLE THROUGH RECREATIONAL USES OF THE GUNPOWDER RIVER ASSOCIATED WITH THE GROUNDWATER OU. BASED ON THE PRELIMINARY DATA AVAILABLE, NO OTHER POTENTIAL PATHWAYS ARE LIKELY TO RESULT IN SIGNIFICANT EXPOSURE UNDER CURRENT LAND-USE CONDITIONS OR FOR ANY FORESEEABLE FUTURE USES. POTENTIAL HUMAN EXPOSURE PATHWAYS UNDER FUTURE LAND-USE CONDITIONS ARE THE SAME AS THOSE NOTED FOR CURRENT LAND USE. INGESTION OF FISH WAS NOT CONSIDERED AS AN EXPOSURE PATHWAY BECAUSE IT IS EXPECTED TO BE LESS SIGNIFICANT THAN THE WORST-CASE DIRECT EXPOSURE OF HUMANS TO THE SURFACE WATERS, AND BECAUSE AVAILABLE DATA ARE NOT SUFFICIENT TO EVALUATE FOOD-CHAIN EXPOSURE POTENTIAL.

EXPOSURE PATHWAYS UNDER CURRENT LAND-USE CONDITIONS WERE EVALUATED QUANTITATIVELY, AND THOSE UNDER FUTURE LAND-USE CONDITIONS WERE EVALUATED QUALITATIVELY. CHRONIC INHALATION EXPOSURES UNDER CURRENT LAND-USE CONDITIONS WERE EVALUATED FOR SITE WORKERS AT NEARBY WORK AREAS. TWO EXPOSURE ESTIMATES WERE GENERATED FOR THESE RECEPTORS BASED ON HIGH AND LOW ESTIMATES OF VOLATILE EMISSIONS FROM WATSON CREEK SURFACE WATER. SURFACE WATER EXPOSURES WERE EVALUATED FOR RECREATIONAL USERS OF THE GUNPOWDER RIVER. THE ESTIMATED HUMAN HEALTH RISKS ASSOCIATED WITH THESE PATHWAYS ARE AS FOLLOWS:

CURRENT LAND USE:

FOR SITE WORKERS, THE UPPER-BOUND EXCESS LIFETIME CANCER RISK RANGES FROM $4 \times (10^{-8})$ TO $3 \times (10^{-7})$ FROM EXPOSURES TO VOLATILE EMISSIONS FROM WATSON CREEK. THE RISK ESTIMATES ARE BELOW THE $1 \times (10^{-6})$ RISK LEVEL OFTEN USED BY REGULATORY AGENCIES TO DETERMINE THE NEED FOR REMEDIATION AT A SITE. FOR ALL RECEPTORS, THE

HAZARD INDEX IS LESS THAN ONE, INDICATING THAT INHALATION EXPOSURES EVALUATED ARE UNLIKELY TO BE ASSOCIATED WITH NONCARCINOGENIC HEALTH EFFECTS.

PERSONS SWIMMING IN THE GUNPOWDER RIVER NEAR OLD O-FIELD ARE NOT LIKELY TO EXPERIENCE SIGNIFICANT HEALTH RISKS DUE TO THE LOW CONCENTRATIONS OF THE CHEMICALS RELATIVE TO TOXIC CONCENTRATIONS. HOWEVER, UNDER THE IMPLAUSIBLE ASSUMPTION OF A PERSON SWIMMING IN THE GUNPOWDER RIVER NEAR OLD O-FIELD EVERY DAY FOR 70 YEARS AND BEING CONTINUOUSLY EXPOSED TO THE MAXIMUM DETECTED CONCENTRATIONS IN THE RIVER, THE EXCESS LIFETIME CANCER RISK WOULD BE IN THE RANGE OF $4 \times (10^{-6})$.

FUTURE LAND USE:

IF ALL INSTITUTIONAL CONTROLS WERE RELAXED, THERE IS THE POSSIBILITY THAT SITE WORKERS COULD BE MORE INTIMATELY EXPOSED TO MATERIALS VOLATILIZED FROM WATSON CREEK. POTENTIAL RISKS TO WORKERS AT OLD O-FIELD EXPOSED VIA INHALATION TO VOLATILE CHEMICALS ARE LIKELY TO BE GREATER THAN THOSE ASSOCIATED WITH CURRENT-USE EXPOSURES. THE RISKS FOR THIS PATHWAY PROBABLY COULD BE INCREASED AN ORDER OF MAGNITUDE ABOVE THOSE ESTIMATED FOR CURRENT-USE SITE WORKERS, GIVEN THAT WORKERS AT OLD O-FIELD WOULD BE CLOSER TO THE EMISSION SOURCE AND COULD BE EXPOSED MORE FREQUENTLY. THUS, EXCESS LIFETIME CANCER RISKS IN THE RANGE OF (10^{-7}) TO (10^{-6}) WOULD BE POSSIBLE. HAZARD INDICES LIKELY WOULD REMAIN BELOW ONE, BUT POTENTIALLY SIGNIFICANT RISKS WOULD BE POSSIBLE FOR NON-CARCINOGENS.

2.3.2 ECOLOGICAL ASSESSMENT SUMMARY

OU ONE HAS BEEN SHOWN TO AFFECT THE SURFACE WATER QUALITY IN WATSON CREEK AND THE GUNPOWDER RIVER, WHICH ARE LOCATED WITHIN THE ENVIRONMENTALLY-SENSITIVE UPPER CHESAPEAKE BAY SYSTEM. O-FIELD HAS NOT BEEN DECLARED A CRITICAL HABITAT FOR THE BALD EAGLE (AN ENDANGERED SPECIES), BUT MOST OF THE SHORELINE IS USED BY THE LARGE BALD EAGLE POPULATION ON APG AS A POTENTIAL FORAGING AND FEEDING AREA. THEIR PRESENCE ON APG CONSTITUTES A VALUABLE RESOURCE AND THE SUPPORTING HABITAT IS IMPORTANT. IN ADDITION, ENDANGERED SPECIES ARE KNOWN TO FREQUENT THE AREA. THEREFORE, POTENTIAL ECOLOGICAL IMPACTS WERE CONSIDERED TO BE PARTICULARLY IMPORTANT AND WERE EVALUATED FOR AQUATIC AND TERRESTRIAL WILDLIFE AT OLD O-FIELD. AQUATIC LIFE EXPOSURES WERE EVALUATED FOR CHEMICALS IN SURFACE WATER AND SEDIMENT IN WATSON CREEK AND THE GUNPOWDER RIVER. IN ADDITION, EXPOSURES WERE EVALUATED FOR BENTHIC SPECIES LIVING IN THE GROUNDWATER DISCHARGE ZONE IN WATSON CREEK. TERRESTRIAL WILDLIFE EXPOSURES WERE EVALUATED FOR HERON (A PISCIVORE), SANDPIPERS (AN AQUATIC INSECTIVORE), AND MUSKRAT (AQUATIC HERBIVORE) FEEDING IN WATSON CREEK AND EXPOSED TO CHEMICALS THAT HAVE ACCUMULATED IN FOOD. THE RESULTS OF THE ECOLOGICAL ASSESSMENT ARE AS FOLLOWS:

AQUATIC LIFE IMPACTS:

* SURFACE WATER EXPOSURES.

AQUATIC LIFE IN WATSON CREEK AND THE GUNPOWDER RIVER ARE PROBABLY BEING IMPACTED BY SURFACE WATER CHEMICAL CONTAMINANTS ASSOCIATED WITH OLD O-FIELD. IMPACTS IN WATSON CREEK ARE LIKELY MORE SEVERE THAN THOSE IN THE GUNPOWDER RIVER, GIVEN THE GREATER NUMBER OF CHEMICALS PRESENT AT HIGHER CONCENTRATIONS IN THE CREEK. ALSO, THE MORE CLOSED NATURE OF WATSON CREEK RELATIVE TO THE GUNPOWDER RIVER PROBABLY MAKES IT MORE SUSCEPTIBLE TO IMPACTS THAN THE RIVER. IMPACTS ASSOCIATED WITH ORGANIC CONTAMINANTS IN WATSON CREEK ARE PROBABLY LOCALIZED TO THE AREA OF GROUNDWATER DISCHARGE, WHICH LIKELY HAS THE HIGHEST CONCENTRATIONS OF VOLATILE ORGANIC CHEMICALS BEING RELEASED TO SURFACE WATER. PREDICTED IMPACTS ON BENTHIC SPECIES LIVING WITHIN THIS AREA WERE GREATER THAN THOSE PREDICTED FOR SPECIES LIVING WITHIN THE WATER COLUMN. IMPACTS ASSOCIATED WITH INORGANIC CONTAMINANTS ARE PROBABLY MORE WIDESPREAD, GIVEN THE RELATIVELY EVEN DISTRIBUTION OF THESE CHEMICALS THROUGHOUT THE CREEK. FURTHER STUDIES OF SURFACE WATER EXPOSURES ARE PLANNED, AND WILL BE DISCUSSED IN THE FINAL ROD.

* SEDIMENT EXPOSURES.

CHEMICAL CONCENTRATIONS IN WATSON CREEK AND THE GUNPOWDER RIVER SEDIMENTS ARE BELOW THOSE PREDICTED TO BE HARMFUL TO AQUATIC LIFE, SUGGESTING THAT AQUATIC LIFE IMPACTS FROM EXPOSURE TO CHEMICALS IN SEDIMENT ARE NOT LIKELY. HOWEVER, THE SEDIMENT TOXICITY VALUES PREDICTED TO BE HARMFUL WERE DERIVED FROM A VERY LIMITED TOXICITY DATABASE AND, THEREFORE, MAY NOT NECESSARILY REFLECT CONDITIONS WHICH ARE PROTECTIVE OF AQUATIC

LIFE. FURTHER STUDIES OF SEDIMENT EXPOSURES ARE PLANNED, AND WILL BE DISCUSSED IN THE FINAL ROD.

TERRESTRIAL WILDLIFE IMPACTS:

* WILDLIFE EXPOSURES.

WILDLIFE FEEDING IN WATSON CREEK COULD BE IMPACTED BY EXPOSURE TO HEAVY METALS IN THEIR FOOD. SANDPIPERS AND OTHER SHORE BIRDS FEEDING ON AQUATIC INSECTS AND PROBABLY BENTHIC ORGANISMS ARE POTENTIALLY AT GREATEST RISK OF IMPACT AS MANY OF THE INORGANIC CHEMICALS PRESENT IN WATSON CREEK CAN BIOACCUMULATE SIGNIFICANTLY IN AQUATIC INVERTEBRATES. PISCIVOROUS BIRD SPECIES, MUCH AS HERON, EAGLES, AND OSPREY DO NOT APPEAR TO BE AT RISK BECAUSE MOST OF THE METALS PRESENT ACCUMULATE TO A LESSER DEGREE IN FISH THAN IN INVERTEBRATES. FURTHER, HERON, EAGLES, AND OSPREY ARE MUCH LESS SUSCEPTIBLE THAN SANDPIPERS AND OTHER SMALL SHORE BIRDS TO IMPACT FROM OLD O-FIELD BECAUSE THEIR FEEDING RANGE IS SO LARGE, THAT FISH IN WATSON CREEK ONLY CONSTITUTE A SMALL PORTION OF THEIR DIET. HERBIVOROUS SPECIES SUCH AS MUSKRAT APPEAR TO BE AT RISK FROM DIETARY EXPOSURES, EVEN THOUGH FEW CHEMICALS IN WATSON CREEK ARE LIKELY TO ACCUMULATE IN AQUATIC PLANTS, BECAUSE THE CHEMICALS THAT COULD ACCUMULATE COULD BE TOXIC AT RELATIVELY LOW DIETARY CONCENTRATIONS. FURTHER STUDIES OF WILDLIFE EXPOSURE ARE PLANNED, AND WILL BE DISCUSSED IN THE FINAL ROD.

2.3.3 CONCLUSIONS OF THE RISK ASSESSMENT

PAST ACTIVITIES AT OLD O-FIELD HAVE RESULTED IN SIGNIFICANT CONTAMINATION OF GROUNDWATER, SURFACE WATER, AND SEDIMENT IN THE AREA. UNDER CURRENT LAND-USE CONDITIONS, ECOLOGICAL POPULATIONS ARE THE PRINCIPAL RECEPTORS OF CONCERN. FEW HUMAN HEALTH EXPOSURE PATHWAYS TO CONTAMINATED GROUNDWATER EXIST UNDER CURRENT LAND-USE CONDITIONS.

IT IS POSSIBLE THAT THE AQUATIC LIFE IN WATSON CREEK AND THE GUNPOWDER RIVER AND TERRESTRIAL WILDLIFE FEEDING IN WATSON CREEK ARE BEING ADVERSELY AFFECTED BY CHEMICAL CONTAMINATION ASSOCIATED WITH OLD O-FIELD. ACUTE AND CHRONIC TOXICITY IN OLD O-FIELD SURFACE WATERS PROBABLY HAS AFFECTED THE COMPOSITION AND STRUCTURE OF THE AQUATIC COMMUNITIES IN WATSON CREEK AND POSSIBLY THE GUNPOWDER RIVER NEAR OLD O-FIELD. LOCALIZED REDUCTIONS IN SPECIES DIVERSITY AND NUMBER FOR RESIDENT AQUATIC LIFE (PARTICULARLY IN WATSON CREEK) ARE POSSIBLE, AS ARE IMPACTS IN NONRESIDENT SPECIES THAT USE THE AREA AS A NURSERY AREA (E.G., BLUEBACK HERRING, BAY ANCHOVY, MENHADEN). CONTAMINATION COULD ALSO RESULT IN LOCALIZED REDUCTIONS IN POPULATION SIZE AND CONTRIBUTE TO CUMULATIVE IMPACTS ASSOCIATED WITH APG AS A WHOLE.

WILDLIFE FEEDING IN WATSON CREEK APPEAR TO BE AT RISK FROM EXPOSURE TO HEAVY METALS IN THE DIET. DIETARY EXPOSURES TO HEAVY METALS CAN INDUCE A VARIETY OF TOXIC EFFECTS IN WILDLIFE INCLUDING DECREASED REPRODUCTIVE SUCCESS, DECREASED GROWTH, AND ABNORMAL BEHAVIOR. SUCH EFFECTS COULD DIRECTLY AFFECT THE HEALTH OF WILDLIFE POPULATIONS IN AND AROUND WATSON CREEK. SUCH LOCALIZED EFFECTS ARE UNLIKELY TO AFFECT THE WILDLIFE POPULATION OF APG AS A WHOLE. NEVERTHELESS, THE PRESENCE OF HEAVY METALS IN WATSON CREEK APPEARS TO HAVE REDUCED THE VALUE OF THAT AREA AS WILDLIFE HABITAT. FURTHER, IMPACTS IN SPECIES IN THE OLD O-FIELD AREA COULD CONTRIBUTE TO CUMULATIVE IMPACTS ASSOCIATED WITH APG AS A WHOLE.

THESE ESTIMATES OF RISK, HOWEVER, ARE NOT DEFINITE AT THIS TIME. THERE IS A GREAT DEAL OF UNCERTAINTY ASSOCIATED WITH ALL RISK ESTIMATES FOR THE OLD O-FIELD STUDY AREA BECAUSE OF LIMITATIONS ASSOCIATED WITH THE AVAILABLE SAMPLING DATA AND LIMITATIONS INHERENT TO THE RISK ASSESSMENT PROCESS. ADDITIONAL INVESTIGATION IS NEEDED TO ASSESS MORE DEFINITELY EXISTING OR POTENTIAL IMPACTS ASSOCIATED WITH THE OLD O-FIELD STUDY AREA.

THE CONCLUSIONS OF THE PRELIMINARY RISK ASSESSMENT ARE THAT: (1) THERE ARE NO SIGNIFICANT HUMAN HEALTH RISKS ASSOCIATED WITH GROUNDWATER OR INTERCONNECTED SURFACE WATER AT OLD O-FIELD IF CURRENT LAND-USE RESTRICTIONS REMAIN IN PLACE; AND 2) THERE IS A POTENTIAL FOR ECOLOGICAL RISKS, ALTHOUGH THEY CANNOT BE QUANTIFIED GIVEN EXISTING DATA. AN INTERIM ACTION FOR THE GROUNDWATER AT OLD O-FIELD IS BEING PURSUED FOR SEVERAL REASONS: (1) SEVERAL CONTAMINANTS HAVE BEEN DETECTED IN THE SURFACE WATER IN WATSON CREEK ABOVE WHICH (TABLE 2); (2) THE CONTAMINATED GROUNDWATER FROM OLD O-FIELD IS KNOWN TO DISCHARGE TO WATSON CREEK; AND (3) CONTAINMENT OF THE CONTAMINATED GROUNDWATER WHILE INVESTIGATING ALTERNATIVES FOR ADDRESSING THE SOURCE OF THE CONTAMINATION WILL PREVENT FURTHER DEGRADATION OF WATSON CREEK AND MITIGATE FUTURE IMPACTS.

SINCE THESE AQUIFERS ARE KNOWN TO DISCHARGE INTO THE SURFACE WATERS OF WATSON CREEK, IF THE PRESENT SITUATION

GOES UNABATED, THE CONTINUED CONTAMINATION OF SURFACE WATER AND SEDIMENTS MAY PRESENT AN IMMINENT AND SUBSTANTIAL ENDANGERMENT TO PUBLIC WELFARE, OR THE ENVIRONMENT. THIS FINDING OF IMMINENT AND SUBSTANTIAL ENDANGERMENT AND THE REMEDY SELECTED HEREIN ARE NOT BASED ON ANY PRESENTLY OBSERVED THREAT TO PUBLIC HEALTH AT OR FROM THE SITE.

#DRA

3.0 DESCRIPTION OF REMEDIAL ALTERNATIVES

GROUNDWATER EXTRACTION/DISCHARGE AND TREATMENT ALTERNATIVES WERE DEVELOPED FOR OU ONE TO SATISFY THE FOLLOWING REMEDIATION OBJECTIVES:

- * PROVIDE CONTAINMENT OF CONTAMINATED ZONES IN THE WATER TABLE AND UPPER CONFINED AQUIFERS AT OLD O-FIELD;
- * MINIMIZE ENVIRONMENTAL RISKS TO SENSITIVE AQUATIC AND TERRESTRIAL ECOSYSTEMS IN WATSON CREEK, THE GUNPOWDER RIVER, AND THE SURROUNDING WETLANDS BY REDUCING OR ELIMINATING DISCHARGE OF CONTAMINATED GROUNDWATER TO THESE AREAS; AND
- * CONTROL POTENTIAL HUMAN HEALTH RISKS ASSOCIATED WITH GROUNDWATER, SURFACE WATER, AND FOOD-CHAIN EXPOSURES THAT COULD RESULT FROM CONTINUED CONTAMINANT MIGRATION IN GROUNDWATER AT OLD O-FIELD.

THESE OBJECTIVES ARE BASED ON THE NATURE AND EXTENT OF CHEMICALLY AFFECTED GROUNDWATER AND ITS ASSOCIATED RISKS AS DISCUSSED IN SECTIONS 2.2 AND 2.3.

IN THE FFS, REMEDIAL TECHNOLOGIES WITH POTENTIAL APPLICATION TO OLD O-FIELD GROUNDWATER INITIALLY WERE IDENTIFIED AND SCREENED BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND RELATIVE COST. TABLE 4 PRESENTS THOSE TECHNOLOGIES CONSIDERED ALONG WITH THE RESULTS OF THE INITIAL SCREENING PROCESS. INDIVIDUAL TECHNOLOGIES RETAINED WERE THEN COMBINED TO FORM A SERIES OF EXTRACTION/DISCHARGE ALTERNATIVES, AND A SEPARATE SERIES OF TREATMENT ALTERNATIVES. BECAUSE 14 GROUNDWATER EXTRACTION/DISCHARGE ALTERNATIVES INITIALLY WERE IDENTIFIED FROM THE REMAINING TECHNOLOGIES, AN INITIAL SCREENING OF THESE ALTERNATIVES WAS PERFORMED AGAIN BASED ON EFFECTIVENESS, COSTS, AND IMPLEMENTABILITY. A SECOND SCREENING OF THOSE ALTERNATIVES REMAINING AFTER THE INITIAL SCREENING WAS THEN PERFORMED USING GROUNDWATER MODELING TO ESTIMATE PERFORMANCE. FOUR EXTRACTION/DISCHARGE ALTERNATIVES REMAINED FOLLOWING THE TWO-STEP SCREENING PROCESS WHICH IS SUMMARIZED IN TABLES 5 AND 6. TREATMENT ALTERNATIVES WERE NOT SCREENED AS ONLY SIX ALTERNATIVES WERE IDENTIFIED FROM REMEDIAL TECHNOLOGIES.

THIS SECTION PRESENTS THE FOUR GROUNDWATER EXTRACTION/DISCHARGE AND SIX GROUNDWATER TREATMENT ALTERNATIVES REMAINING FOLLOWING INITIAL SCREENING PERFORMED IN THE FFS. NOTE THAT ALL COST AND IMPLEMENTATION TIMES PRESENTED ARE ESTIMATED. THE ALTERNATIVES DESCRIBED HEREIN ARE COMPARED AGAINST DETAILED EVALUATION CRITERIA IN SECTION 4.0 IN ORDER TO SELECT A PREFERRED REMEDY FOR OLD O-FIELD GROUNDWATER. A DISCUSSION OF CLEANUP CRITERIA IS PRESENTED AS A NECESSARY PRELUDE TO THE REMEDIAL ALTERNATIVE DISCUSSION.

3.1 CLEANUP CRITERIA

AS PREVIOUSLY NOTED, EXISTING DATA FOR GROUNDWATER (TABLE 1), SURFACE WATER (TABLE 2), AND SEDIMENT (TABLE 3) AT OLD O-FIELD ARE SUFFICIENT TO INDICATE AQUATIC LIFE IN WATSON CREEK MAY BE IMPACTED BY CHEMICAL CONTAMINATION MIGRATING IN GROUNDWATER FROM THE LANDFILL AREA. HOWEVER, THESE DATA DO NOT PROVIDE A COMPREHENSIVE BASIS FOR ESTABLISHING CHEMICAL-SPECIFIC TARGET CLEANUP GOALS BECAUSE OF: (1) THE COMPLEX, MULTIMEDIA EXPOSURE PATHWAYS FOR THE SITE; (2) INSUFFICIENT ECOTOXICOLOGICAL DATA ON MANY OF THE CHEMICALS OF POTENTIAL CONCERN (E.G., THIODIGLYCOL); AND (3) THE NEED FOR ADDITIONAL SURFACE WATER, SEDIMENT, AND BIOLOGICAL DATA FOR WATSON CREEK.

MAXIMUM CONTAMINANT LEVELS (MCLS) PROMULGATED BY THE SAFE DRINKING WATER ACT AND AWQCS FOR THE PROTECTION OF

AQUATIC LIFE PROMULGATED PURSUANT TO THE CLEAN WATER ACT COULD BE CONSIDERED RELEVANT AND APPROPRIATE REQUIREMENTS FOR WATSON CREEK AND THE GUNPOWDER RIVER. THESE ARE PRESENTED FOR THE CONTAMINANTS OF CONCERN AT THE SITE IN TABLE 7. MCLS ARE BASED ON HEALTH EFFECTS ASSOCIATED WITH THE CHEMICAL AND THE TECHNICAL CAPABILITIES AVAILABLE TO DETECT AND TREAT THAT CHEMICAL. AWQCS ARE RISK-BASED STANDARDS ESTABLISHED FOR THE PROTECTION OF AQUATIC ORGANISMS AS WELL AS HUMAN HEALTH. AWQCS ARE BASED ON EXPOSURES RELATED TO DIRECT CONTACT, INGESTION OF CONTAMINATED WATER, AND INGESTION OF CONTAMINATED ORGANISMS (I.E., FOOD-CHAIN EXPOSURES). MCLS MAY NOT BE AS APPROPRIATE AS AWQCS FOR THE OLD O-FIELD SITE BECAUSE NEITHER THE GROUNDWATER, WATSON CREEK, NOR THE GUNPOWDER RIVER ARE USED FOR DRINKING WATER AND THE PRELIMINARY RISK ASSESSMENT HAS SHOWN THAT HUMAN HEALTH RISKS ARE NOT SIGNIFICANT WHILE ECOLOGICAL RISKS, ALTHOUGH NOT QUANTIFIABLE, MAY POTENTIALLY EXIST. THE CONTAINMENT OF GROUNDWATER AS AN INTERIM ACTION FOR OU ONE WOULD REDUCE THE DISCHARGE OF CONTAMINATION INTO SURFACE WATER BODIES, AND AWQCS ARE CONSIDERED RELEVANT AND APPROPRIATE REQUIREMENTS EVEN THOUGH THE SOURCE OF CONTAMINATION REMAINS.

AN EVALUATION OF THE SURFACE WATER DATA FROM THE HGA INDICATES THE CONTAMINANT LEVELS IN WATSON CREEK PERIODICALLY HAVE EXCEEDED AWQCS FOR ARSENIC (TRIVALENT), ARSENIC (PENTAVALENT), MERCURY, AND THE FISH CONSUMPTION LOWEST OBSERVED EFFECT LEVEL FOR 1,1,2,2-TETRACHLOROETHANE. THE ARSENIC AND MERCURY LEVELS ALSO ARE ABOVE THE WATER QUALITY STANDARDS PROMULGATED (PENTAVALENT) BY THE STATE OF MARYLAND, ALSO PRESENTED IN TABLE 7. THESE AMBIENT WATER QUALITY CRITERIA AND WATER QUALITY STANDARDS, TOGETHER WITH EFFLUENT LIMITATIONS ESTABLISHED UNDER THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES), MAY BE CONSIDERED RELEVANT AND APPROPRIATE REQUIREMENTS FOR THIS ACTION, BECAUSE CONTAMINATED GROUNDWATER DISCHARGE TO THE SURFACE WATER BODY MAY CONTRIBUTE TO THE OBSERVED CONCENTRATIONS. IN ADDITION TO THE ABOVE-MENTIONED CONTAMINANTS, SEVERAL CHLORINATED VOCs HAVE BEEN DETECTED PERIODICALLY IN WATSON CREEK; AS NOTED IN THE PRELIMINARY RISK ASSESSMENT, IT IS POSSIBLE THAT SOME OF THESE COMPOUNDS MAY BE PRESENT AT LEVELS EXCEEDING AWQCS OR OTHER STANDARDS DURING TRANSIENT CONDITIONS OF "PULSE" DISCHARGE OF CONTAMINATED GROUNDWATER. MCLS AND AWQCS HAVE NOT BEEN ESTABLISHED FOR THIODIGLYCOL, 1,4-DITHIANE, AND OTHER CHEMICAL-AGENT DEGRADATION PRODUCTS FOUND IN GROUNDWATER AT OLD O-FIELD.

3.2 GROUNDWATER EXTRACTION/DISCHARGE ALTERNATIVES

FOUR GROUNDWATER EXTRACTION/DISCHARGE ALTERNATIVES WERE RETAINED FOR OU ONE FOLLOWING THE TWO-STEP SCREENING PROCESS IN THE FFS. THESE ALTERNATIVES, NUMBERED TO CORRESPOND WITH THE NUMBERS IN THE FFS REPORT, ARE AS FOLLOWS:

ALTERNATIVE E-1:	DOWNGRADIENT EXTRACTION WITH DISCHARGE TO SURFACE WATER
ALTERNATIVE E-4:	CIRCUMFERENTIAL EXTRACTION WITH CAPPING AND DISCHARGE TO SURFACE WATER
ALTERNATIVE E-5:	CIRCUMFERENTIAL EXTRACTION WITH SPRAY IRRIGATION/SOURCE FLUSHING
ALTERNATIVE E-6:	CIRCUMFERENTIAL EXTRACTION WITH DOWNGRADIENT REINJECTION

PROPOSED DOWNGRADIENT AND CIRCUMFERENTIAL EXTRACTION WELL NETWORKS FOR OLD O-FIELD ARE SHOWN IN FIGURE 6.

3.2.1 COMMON ELEMENTS

ALL OF THE GROUNDWATER EXTRACTION/DISCHARGE ALTERNATIVES CONSIDERED FOR THE SITE INCLUDE A NUMBER OF COMMON COMPONENTS. ALL OF THE EXTRACTION SYSTEMS HAVE BEEN DEVELOPED TO PROVIDE COMPLETE CAPTURE OF THE CONTAMINATED GROUNDWATER PLUME THAT IS DISCHARGING TO WATSON CREEK THROUGH THE WATER-TABLE AND UPPER CONFINED AQUIFERS. ALL EXTRACTION WELLS WILL BE CONSTRUCTED OF 6-INCH DIAMETER TYPE 304 STAINLESS-STEEL WIRE-WRAPPED SCREEN AND RISER, AND SUBMERSIBLE PUMPS WILL BE REQUIRED FOR ALL WELLS. DUE TO CHEMICAL AGENT AND EXPLOSIVE HAZARDS THAT EXIST AT OLD O-FIELD, ALL DRILLING ASSOCIATED WITH NEW WELL INSTALLATION MUST BE PERFORMED REMOTELY AND CANNOT BE PERFORMED SAFELY DURING DOWNRANGE ORDNANCE TESTING OPERATIONS OR DURING WEATHER CONDITIONS THAT COULD ALLOW FOR A CONTAMINATED PLUME TO DISPERSE INTO POPULATED AREAS. EXTRACTED WATER WILL

BE PIPED TO AN ON-SITE TREATMENT SYSTEM FOR TREATMENT PRIOR TO DISCHARGE. ABOVEGROUND PIPING WILL BE USED FOR TRANSFERRING GROUNDWATER FROM THE WELLHEADS TO THE ON-SITE TREATMENT SYSTEM TO AVOID DANGEROUS AND EXPENSIVE EXCAVATION REQUIRED FOR BURIAL OF PIPING.

EACH ALTERNATIVE INCLUDES LONG-TERM GROUNDWATER AND SURFACE WATER MONITORING IN COMPLIANCE WITH REQUIREMENTS OF RCRA SUBPART F, 40 CFR S 264.91 - 264.100. THESE MONITORING ACTIVITIES WILL BE CONDUCTED TO GAUGE THE EFFECTIVENESS OF THE SELECTED REMEDY. THIS EFFECTIVENESS/PERFORMANCE MONITORING PROGRAM WILL INCLUDE AN OFF-SITE MONITORING PLAN FOR GROUNDWATER, SURFACE WATER, SEDIMENT, AND BIOTA IN PROXIMITY TO OLD O-FIELD; INSTALLATION OF ADDITIONAL MONITORING WELLS; AND CLOSURE OF EXISTING WELLS THAT ARE SCREENED IN THE LOWER CONFINED AQUIFER TO PREVENT POSSIBLE CROSS-CONTAMINATION OF THIS UNIT. ANY WELLS THAT ARE DAMAGED, UNUSABLE, OR NO LONGER NECESSARY FOR THE MONITORING PROGRAM WILL BE CLOSED IN ACCORDANCE WITH FEDERAL AND STATE REQUIREMENTS.

IT SHOULD ALSO BE NOTED THAT ALL EXTRACTION/DISCHARGE ALTERNATIVES AND ASSOCIATED COST ESTIMATES WERE DEVELOPED UNDER TWO MAJOR ASSUMPTIONS: (1) THAT THE EXTRACTION WELL NETWORK WOULD INCORPORATE EXISTING 4-INCH PVC MONITORING WELLS TO THE EXTENT PRACTICABLE; AND (2) THAT EXTRACTION WOULD BE ACHIEVED FROM BOTH AQUIFERS (WATER-TABLE AND UPPER CONFINED) THROUGH THE USE OF EXTRACTION WELL PAIRS, WITH ONE WELL IN THE PAIR SCREENED IN EACH AQUIFER. THE FIRST ASSUMPTION WAS MADE BECAUSE OF THE HIGH COST AND LOGISTICAL DIFFICULTIES (E.G., THE PREVIOUSLY-MENTIONED REMOTE DRILLING REQUIREMENTS) INVOLVED IN EXTRACTION WELL INSTALLATION, WHILE THE SECOND ASSUMPTION WAS BASED ON HYDROGEOLOGIC DATA AND GROUNDWATER MODELING RESULTS FROM THE HGA THAT SUGGESTED THE TWO AQUIFERS WERE HYDROLOGICALLY SEPARATE SYSTEMS.

HOWEVER, DATA GENERATED DURING SUBSEQUENT AQUIFER TESTING ACTIVITIES AT THE SITE (REFER TO SECTION 4.2.1) SHOWED EXISTING WELLS WERE UNSUITABLE FOR USE IN AN EXTRACTION SYSTEM BECAUSE OF SHORT SCREENED INTERVALS AND POOR EFFICIENCY. IN ADDITION, DATA ON VERTICAL LEAKAGE BETWEEN THE WATER-TABLE AND UPPER CONFINED AQUIFERS INDICATE THE TWO SYSTEMS ARE HYDRAULICALLY INTERCONNECTED TO SOME EXTENT, AND THERE COULD BE COST AND OPERATIONAL ADVANTAGES TO CONSTRUCTING SINGLE EXTRACTION WELLS SCREENED THROUGH BOTH AQUIFERS. THUS, THESE ASSUMPTIONS, WHICH SERVED AS A PARTIAL BASIS FOR COST ESTIMATES GENERATED DURING THE FFS, MAY NOT BE APPLICABLE TO ACTUAL SITE CONDITIONS AS ENCOUNTERED DURING THE AQUIFER TESTING PROGRAM. HOWEVER, CONSIDERABLE UNCERTAINTY STILL EXISTS REGARDING THE OPTIMAL NUMBER AND DETAILED DESIGN OF EXTRACTION WELLS FOR THE SELECTED REMEDY, AND INSTALLATION OF LARGE-DIAMETER TEST WELLS AND ADDITIONAL AQUIFER TESTING WILL BE REQUIRED BEFORE THE REMEDY CAN BE DESIGNED. THEREFORE, THE FFS COST ESTIMATES HAVE BEEN MAINTAINED, BECAUSE THEY PROVIDE A CONSISTENT BASIS FOR DIRECT COMPARISON OF THE EXTRACTION/DISCHARGE ALTERNATIVES.

3.2.2 ALTERNATIVE E-1 - DOWNGRADIENT EXTRACTION WITH-DISCHARGE TO SURFACE WATER

ALTERNATIVE E-1 CONSISTS OF THE INSTALLATION OF A DOWNGRADIENT EXTRACTION WELL NETWORK WITH DISCHARGE TO SURFACE WATER FOLLOWING APPROPRIATE TREATMENT. THE DOWNGRADIENT EXTRACTION WELL NETWORK WILL CONSIST OF SEVEN EXTRACTION WELL PAIRS (ONE IN THE WATER-TABLE AQUIFER AND ONE IN THE UPPER CONFINED AQUIFER) FOR A TOTAL OF 14 WELLS. EXISTING WELLS WHICH ARE NOT CLOSED WILL NOT BE USED AS PART OF THE EXTRACTION SYSTEM DUE TO THEIR INEFFICIENCY. THEY MAY, HOWEVER, BE USED FOR MONITORING PURPOSES. THE TOTAL EXTRACTION RATE FOR THIS SYSTEM UNDER HIGH RECHARGE/HIGH FLOW CONDITIONS HAS BEEN ESTIMATED AT 21.9 GALLONS PER MINUTE (GPM).

THE TREATED GROUNDWATER WILL BE DISCHARGED TO THE GUNPOWDER RIVER OR WATSON CREEK. THE SUBSTANTIVE ASPECTS OF AN NPDES PERMIT AS REQUIRED BY THE CLEAN WATER ACT INCLUDING WEEKLY MONITORING FOR SELECTED PARAMETERS, BIOMONITORING, AND PERIODIC PRIORITY POLLUTANT SCANS WILL BE REQUIRED TO BE MET FOR DISCHARGE OF THE TREATED GROUNDWATER.

ALTERNATIVE E-1 HAS AN ESTIMATED CAPITAL COST OF \$ 504,000 AND OPERATION AND MAINTENANCE COSTS OF \$81,650. ITS PRESENT WORTH IS ESTIMATED AT \$1,763,000 FOR A 30-YEAR PERIOD AT A 5 PERCENT DISCOUNT RATE. THE INSTALLATION OF THE DOWNGRADIENT EXTRACTION SYSTEM WILL REQUIRE APPROXIMATELY 12 MONTHS TO IMPLEMENT.

3.2.3 ALTERNATIVE E-4 - CIRCUMFERENTIAL EXTRACTION WITH CAPPING AND DISCHARGE TO SURFACE WATER

ALTERNATIVE E-4 CONSISTS OF THE CONSTRUCTION AND INSTALLATION OF A CIRCUMFERENTIAL EXTRACTION WELL NETWORK, THE CONSTRUCTION AND INSTALLATION OF A LOW-PERMEABILITY MULTI-LAYER CAP, TREATMENT OF GROUNDWATER IN ACCORDANCE WITH THE SELECTED TREATMENT ALTERNATIVE, AND DISCHARGE TO SURFACE WATER. THIS ALTERNATIVE WILL

MEET TWO OBJECTIVES FOR GROUNDWATER CONTAMINANT CONTROL: WASTE ISOLATION AND MIGRATION CONTROL. INSTALLATION OF THE CAP WILL RESTRICT PRECIPITATION INFILTRATION THROUGH THE WASTE MATERIALS, AND CIRCUMFERENTIAL EXTRACTION OF GROUNDWATER WILL LOWER THE WATER TABLE SUFFICIENTLY TO PREVENT CONTACT WITH THE WASTE MATERIALS IN THE DISPOSAL AREA. ALTHOUGH CAPPING IS PRIMARILY CONSIDERED A SOURCE CONTROL REMEDY, IT OFFERS ADDITIONAL BENEFITS FOR GROUNDWATER REMEDIATION AT THE OLD O-FIELD SITE (AS NOTED ABOVE) AND, THEREFORE, IS BEING CONSIDERED AS A COMPONENT TECHNOLOGY FOR GROUNDWATER EXTRACTION/DISCHARGE ALTERNATIVES FOR THE FIELD.

THE CIRCUMFERENTIAL EXTRACTION WELL NETWORK WILL CONSIST OF 13 EXTRACTION WELLS OR WELL PAIRS FOR A TOTAL OF 26 WELLS. EXISTING WELLS WHICH ARE NOT CLOSED WILL NOT BE USED AS PART OF THE EXTRACTION SYSTEM DUE TO THEIR INEFFICIENCY. THEY MAY, HOWEVER, BE USED FOR MONITORING PURPOSES. THE ESTIMATED TOTAL EXTRACTION RATE FOR THE CIRCUMFERENTIAL EXTRACTION SYSTEM WITH CAPPING IS 20.6 GPM. A LOW-PERMEABILITY, MULTI-LAYER CAP WILL BE INSTALLED OVER THE CONTAMINATION SOURCE AREA AND WILL CONFORM TO RCRA LANDFILL CLOSURE REQUIREMENTS IN 40 CFR S 264.310, WHICH, AMONG OTHER THINGS, INCLUDES AN IMPERMEABLE HIGH DENSITY POLYETHYLENE (HDPE) LINER. THE CAP WILL BE INSTALLED BY FIRST ADVANCING A THICK CLAY LAYER ACROSS THE SITE, USING A BULLDOZER, TO PREVENT DIRECT CONTACT BETWEEN THE SITE SURFACE AND HEAVY EQUIPMENT, THEREBY MINIMIZING POTENTIAL EXPLOSIVE AND DIRECT CONTACT HAZARDS DURING CAP CONSTRUCTION.

THE EXTRACTED GROUNDWATER WILL BE TREATED IN ACCORDANCE WITH THE SELECTED TREATMENT ALTERNATIVE. THE TREATED GROUNDWATER WILL BE DISCHARGED TO THE GUNPOWDER RIVER OR WATSON CREEK. DISCHARGE OF TREATED GROUNDWATER WILL REQUIRE THAT SUBSTANTIVE REQUIREMENTS OF AN NPDES PERMIT BE MET, INCLUDING WEEKLY MONITORING OF THE EFFLUENT FOR SELECTED PARAMETERS AND PERIODIC PRIORITY POLLUTANT SCANS.

ALTERNATIVE E-4 HAS AN ESTIMATED CAPITAL COST OF \$2,598,000 AND OPERATION AND MAINTENANCE COSTS OF \$97,000. ITS PRESENT WORTH IS ESTIMATED AT \$4,078,000 FOR A 30-YEAR PERIOD AT A 5 PERCENT DISCOUNT RATE. ALTERNATIVE E-4 WILL REQUIRE APPROXIMATELY 24 TO 36 MONTHS TO IMPLEMENT.

3.2.4 ALTERNATIVE E-5 - CIRCUMFERENTIAL EXTRACTION WITH SPRAY IRRIGATION/SOURCE FLUSHING

ALTERNATIVE E-5 CONSISTS OF CIRCUMFERENTIAL EXTRACTION WITH SPRAY IRRIGATION/SOURCE FLUSHING. THE SAME CIRCUMFERENTIAL EXTRACTION SYSTEM DESCRIBED IN ALTERNATIVE E-4 WILL BE USED; HOWEVER, THE TOTAL EXTRACTION RATE IS ESTIMATED AT 46.1 GPM TO ENSURE EFFECTIVE CAPTURE OF THE ADDITIONAL WATER INFILTRATING THE LANDFILL FROM THE SPRAY IRRIGATION SYSTEM. APPROXIMATELY HALF OF THE TREATED WATER WILL BE RE-APPLIED TO THE LANDFILL USING A SPRAY IRRIGATION SYSTEM; THE REMAINDER OF THE TREATED WATER WILL BE DISCHARGED TO THE GUNPOWDER RIVER OR WATSON CREEK. THIS ALTERNATIVE IS A HIGHLY AGGRESSIVE APPROACH IN WHICH WATER IS RE-APPLIED TO WASTE MATERIALS TO EFFECT MORE RAPID SOURCE DEGRADATION, AS WELL AS TO PROVIDE ADDITIONAL RECHARGE FOR ENHANCED AQUIFER FLUSHING. RE-APPLICATION OF WATER TO THE SOURCE AREA WILL RESULT IN ADDITIONAL LEACHING AND MOBILIZATION OF SOIL-BOUND OR SOLID-PHASE CONTAMINANTS TO GROUNDWATER FOR SUBSEQUENT EXTRACTION AND TREATMENT. IT MAY ALSO ENHANCE THE DEGRADATION OF BURIED MUNITIONS AND METAL CONTAINERS, RESULTING IN MORE RAPID EXTRACTION AND TREATMENT OF THEIR CONTENTS. WHILE THERE MAY BE DISADVANTAGES TO ENHANCING SOURCE DEGRADATION IN THIS MANNER, THIS ALTERNATIVE REPRESENTS THE MOST AGGRESSIVE APPROACH WITHOUT REMOVING THE SOURCE.

DISCHARGE TO GUNPOWDER RIVER OR WATSON CREEK WILL REQUIRE MEETING THE SUBSTANTIVE ASPECTS OF AN NPDES PERMIT, WITH REQUIRED EFFLUENT MONITORING CONDUCTED WEEKLY.

ALTERNATIVE E-5 HAS AN ESTIMATED CAPITAL COST OF \$1,324,000 AND OPERATION AND MAINTENANCE COSTS OF \$110,000. ITS PRESENT WORTH IS ESTIMATED AT \$3,027,000 FOR A 30-YEAR PERIOD AT A 5 PERCENT DISCOUNT RATE. ALTERNATIVE E-5 WILL REQUIRE APPROXIMATELY 36 TO 60 MONTHS TO IMPLEMENT.

3.2.5 ALTERNATIVE E-6 - CIRCUMFERENTIAL EXTRACTION WITH DOWNGRADIENT RE-INJECTION

ALTERNATIVE E-6 CONSISTS OF CIRCUMFERENTIAL EXTRACTION WITH DOWNGRADIENT RE-INJECTION. THE PROPOSED EXTRACTION SYSTEM IS A MODIFIED CIRCUMFERENTIAL NETWORK THAT INCLUDES 21 RATHER THAN 26 WELLS (CIRCUMFERENTIAL WELLS ARE NOT INCLUDED ON THE WESTERN BOUNDARY OF THE LANDFILL IN THE UPPER CONFINED AQUIFER). THUS, THE SYSTEM IS ACTUALLY A CIRCUMFERENTIAL SYSTEM IN THE WATER-TABLE AQUIFER AND A DOWNGRADIENT SYSTEM IN THE UPPER CONFINED AQUIFER. THE TOTAL EXTRACTION RATE FOR THIS SYSTEM IS ESTIMATED AT 34.3 GPM. ALL OF THE EXTRACTED GROUNDWATER WILL BE RE-INJECTED, FOLLOWING TREATMENT, INTO THE UPPER CONFINED

AQUIFER AT 11 INJECTION WELLS LOCATED DOWNGRAIENT OF THE LANDFILL NEAR THE SHORELINE OF WATSON CREEK; HOWEVER, A CONTINGENCY FOR SURFACE DISCHARGE OF SOME WATER HAS BEEN INCLUDED IN THIS ALTERNATIVE.

THEREFORE, MONITORING AND OTHER REQUIREMENTS OF BOTH RE-INJECTION PERMITS PURSUANT TO FEDERAL AND STATE UNDERGROUND INJECTION CONTROL REGULATIONS AND AN NPDES PERMIT WILL BE REQUIRED FOR THIS ALTERNATIVE.

THIS IS A HIGHLY COMPLEX SYSTEM WITH REGARD TO DESIGN, OPERATION, AND PERFORMANCE MONITORING; HOWEVER, THIS ALTERNATIVE MAY PROVIDE NECESSARY RECHARGE FOR ADDITIONAL AQUIFER FLUSHING AND CONTROL OF INDUCED INFILTRATION FROM WATSON CREEK AND ASSOCIATED WETLANDS BY CREATING A HYDROLOGIC BARRIER (OR "FRESHWATER RIDGE") BETWEEN THESE WATER BODIES AND THE CONTAMINATED PORTIONS OF THE WATER-TABLE AND UPPER CONFINED AQUIFERS.

ALTERNATIVE E-6 HAS AN ESTIMATED CAPITAL COST OF \$1,420,000 AND OPERATION AND MAINTENANCE COSTS OF \$104,000. ITS PRESENT WORTH IS ESTIMATED AT \$3,004,000 FOR A 30-YEAR PERIOD AT A 5 PERCENT DISCOUNT RATE. ALTERNATIVE E-6 WILL REQUIRE APPROXIMATELY 36 TO 60 MONTHS TO IMPLEMENT.

3.3 GROUNDWATER TREATMENT ALTERNATIVES

SIX GROUNDWATER TREATMENT ALTERNATIVES WERE IDENTIFIED FOR OU ONE IN THE FFS. THESE ALTERNATIVES, NUMBERED TO CORRESPOND WITH THE NUMBERS IN THE FFS REPORT, ARE AS FOLLOWS:

ALTERNATIVE T-1: NO ACTION

ALTERNATIVE T-2: MINIMAL ACTION

ALTERNATIVE T-3: CHEMICAL PRECIPITATION/AIR STRIPPING/CARBON ADSORPTION (LIQUID PHASE)

ALTERNATIVE T-4: CHEMICAL PRECIPITATION/ULTRAVIOLET-OXIDATION

ALTERNATIVE T-5: CHEMICAL PRECIPITATION/ACTIVATED SLUDGE BIOLOGICAL TREATMENT/CARBON ADSORPTION

ALTERNATIVE T-6: CHEMICAL PRECIPITATION/POWDERED ACTIVATED CARBON TREATMENT (PACT)

3.3.1 COMMON ELEMENTS

ALL OF THE ACTIVE GROUNDWATER TREATMENT ALTERNATIVES (ALTERNATIVES T-3 THROUGH T-6) CONSIDERED FOR THE SITE INCLUDE A NUMBER OF COMMON COMPONENTS. IMPLEMENTATION OF EACH TREATMENT ALTERNATIVE WILL REQUIRE SITE CLEARING AND PREPARATION; CONSTRUCTION OF A TREATMENT BUILDING, INSTALLATION OF A CONCRETE PAD AND CONTAINMENT SYSTEM; EXTENSION OF WATER AND ELECTRICAL LINES; LONG-TERM SYSTEM OPERATION; LONG-TERM INFLUENT AND EFFLUENT MONITORING INCLUDING CHEMICAL ANALYSIS AND BIOTOXICITY TESTING; LONG-TERM GROUNDWATER MONITORING IN COMPLIANCE WITH REQUIREMENTS OF RCRA SUBPART F, 40 CFR SS 264.90-264.101 AND A NPDES PERMIT; AND PERIODIC REVIEWS OF SITE CONDITIONS AS LONG AS CHEMICALLY AFFECTED MEDIA REMAIN AT THE SITE (I.E., THE SOURCE), IN ACCORDANCE WITH CERCLA S 121(C), 42 USC S 9621(C), THE NCP, AND APPLICABLE EPA GUIDANCE.

WATER IS DISCHARGED TO THE GUNPOWDER RIVER TO ENSURE THAT CHEMICAL-SPECIFIC FEDERAL AND STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) AND THE SUBSTANTIVE REQUIREMENTS OF AN NPDES PERMIT ARE SATISFIED. MONITORING WILL INVOLVE CHEMICAL SAMPLING AS WELL AS ACUTE AND CHRONIC BIOTOXICITY TESTING. IN THE EVENT THAT MONITORING INDICATES ARARS OR NPDES SUBSTANTIVE REQUIREMENTS ARE NOT ACHIEVED, TREATMENT SYSTEM OPERATING PARAMETERS WILL BE MODIFIED TO IMPROVE PERFORMANCE SUCH THAT THE REQUIREMENTS ARE SATISFIED.

IF THE CONTAMINANT SOURCE (I.E., THE BURIED MUNITIONS AND CHEMICAL AGENTS) REMAINS, CHEMICALS WILL CONTINUE TO LEACH INTO THE GROUNDWATER FAR INTO THE FUTURE, EVEN IF A CAP IS CONSTRUCTED OVER THE FIELD TO ISOLATE THE WASTES. GIVEN THE NEED FOR GROUNDWATER TREATMENT TO CONTINUE FOR A LONG PERIOD OF TIME, IT MAY BECOME NECESSARY TO REPLACE THE ENTIRE TREATMENT SYSTEM ONE OR MORE TIMES DURING THE REMEDIAL ACTION LIFETIME.

REPLACEMENT TIMES WILL BE APPROXIMATELY THE SAME FOR ANY OF THE GROUNDWATER TREATMENT ALTERNATIVES; THEREFORE, FOR COMPARATIVE PURPOSES, WE HAVE ASSUMED THAT THE TREATMENT EQUIPMENT WILL BE MAINTAINED AT LEAST 30 YEARS.

3.3.2 ALTERNATIVE T-1 - NO ACTION

THE SUPERFUND PROGRAM REQUIRES THAT THE "NO ACTION" ALTERNATIVE BE EVALUATED AT EVERY SITE TO ESTABLISH A BASELINE FOR COMPARISON. UNDER THIS ALTERNATIVE, THE ARMY WOULD TAKE NO FURTHER ACTION AT THE SITE TO PREVENT EXPOSURE TO THE GROUNDWATER CONTAMINATION.

ALTERNATIVE T-1 DOES NOT HAVE ASSOCIATED CAPITAL AND OPERATION AND MAINTENANCE COSTS, AND WILL NOT REQUIRE ANY TIME FOR IMPLEMENTATION.

3.3.3 ALTERNATIVE T-2 - MINIMAL ACTION

ALTERNATIVE T-2 CONSISTS OF IMPLEMENTATION OF INSTITUTIONAL RESTRICTIONS SUCH AS ACCESS RESTRICTIONS, AND LAND USE RESTRICTIONS; PUBLIC EDUCATION PROGRAMS TO INFORM WORKERS AND LOCAL RESIDENTS OF THE POTENTIAL SITE DANGERS; EMERGENCY PROVISIONS; LONG-TERM ENVIRONMENTAL MONITORING INCLUDING QUARTERLY GROUNDWATER MONITORING; AND FIVE-YEAR REVIEWS AS REQUIRED BY CERCLA S 121(C), 42 USC S 9621(C), THE NCP, AND APPLICABLE EPA GUIDANCE WHEN HAZARDOUS CHEMICALS REMAIN UNTREATED. ASPECTS OF ALTERNATIVE T-2 ARE ALSO INCLUDED IN EACH OF THE ACTIVE GROUNDWATER TREATMENT ALTERNATIVES (ALTERNATIVES T-23 THROUGH T-6).

ALTERNATIVE T-2 HAS AN ESTIMATED CAPITAL COST OF \$50,000 AND OPERATION AND MAINTENANCE COSTS OF \$104,000. ITS PRESENT WORTH IS ESTIMATED AT \$1,692,000 FOR A 30-YEAR PERIOD AT A 5 PERCENT DISCOUNT RATE. ALTERNATIVE T-2 WILL REQUIRE APPROXIMATELY SIX OR LESS MONTHS TO IMPLEMENT.

3.3.4 ALTERNATIVE T-3 - CHEMICAL PRECIPITATION/AIR STRIPPING/CARBON ADSORPTION (LIQUID PHASE)

ALTERNATIVE T-3 CONSISTS OF THE THREE MOST COMMON GROUNDWATER TREATMENT TECHNOLOGIES: CHEMICAL PRECIPITATION, AIR STRIPPING, AND LIQUID-PHASE CARBON ADSORPTION. CHEMICAL PRECIPITATION WILL PROVIDE THE NECESSARY TREATMENT FOR REDUCTION OF INORGANIC CONTAMINANT AND THE COMBINATION OF AIR STRIPPING FOLLOWED BY CARBON ADSORPTION WILL PROVIDE THE NECESSARY TREATMENT FOR REDUCTION OF ORGANIC CONTAMINANT CONCENTRATIONS. CHEMICAL PRECIPITATION INVOLVES MODIFYING THE CHEMICAL STRUCTURE OF METALLIC COMPOUNDS SUCH THAT THEY PRECIPITATE OUT OF SOLUTION AS SOLIDS, FLOCCULATE TOGETHER, AND SETTLE OUT OF THE WATER BY GRAVITY. THIS PROCESS WILL PRODUCE SLUDGE CONTAINING THE METAL CONTAMINANTS WHICH WILL BE DEWATERED IN A FILTER PRESS. THE RESULTANT FILTER CAKE WILL BE PROPERLY DISPOSED AT A FACILITY PERMITTED TO ACCEPT SUCH WASTE.

AIR STRIPPING IS A MASS TRANSFER PROCESS IN WHICH VOLATILE ORGANIC COMPOUNDS (VOCs) DISSOLVED IN THE GROUNDWATER ARE TRANSFERRED TO THE VAPOR PHASE BY COUNTERCURRENT CONTACT WITH A STREAM OF AIR. AIR POLLUTION CONTROLS SUCH AS A VAPOR-PHASE CARBON ADSORPTION UNIT OR A CATALYTIC CONVERTER WILL BE REQUIRED TO REDUCE VOC EMISSIONS AND COMPLY WITH AIR REGULATIONS. CARBON ADSORPTION INVOLVES PHYSICALLY ADSORBING ORGANIC COMPOUNDS FROM THE GROUNDWATER ONTO POROUS CARBON MEDIA CONTAINING SITES PREPARED TO ACCEPT THE CONTAMINANTS. BECAUSE MANY VOCs WILL BE REMOVED THROUGH AIR STRIPPING, ORGANIC LOADING ON THE CARBON WILL BE REDUCED. CARBON ADSORPTION WILL, THEREFORE, BE USED PRIMARILY FOR REMOVAL OF LESS VOLATILE ORGANIC COMPOUNDS. SPENT VAPOR AND LIQUID-PHASE CARBON WILL REQUIRE PROPER OFF-SITE DISPOSAL OR REGENERATION.

ALTERNATIVE T-3 HAS AN ESTIMATED CAPITAL COST OF \$1,263,000 AND OPERATION AND MAINTENANCE COSTS OF \$525,000. ITS PRESENT WORTH IS ESTIMATED AT \$9,392,000 FOR A 30-YEAR PERIOD AT A 5 PERCENT DISCOUNT RATE. ALTERNATIVE T-3 WILL REQUIRE APPROXIMATELY 18 TO 24 MONTHS TO IMPLEMENT.

3.3.5 ALTERNATIVE T-4 - CHEMICAL PRECIPITATION/ULTRAVIOLET-OXIDATION

ALTERNATIVE T-4 CONSISTS OF CHEMICAL PRECIPITATION FOR REDUCTION OF INORGANIC CONTAMINANT CONCENTRATIONS AND ULTRA-VIOLET (UV) OXIDATION FOR REDUCTION OF ORGANIC CONTAMINANT CONCENTRATIONS. UV-OXIDATION IS AN EMERGING TECHNOLOGY WHICH USES ULTRAVIOLET LIGHT IN CONJUNCTION WITH A STRONG OXIDIZING AGENT, SUCH AS HYDROGEN PEROXIDE OR OZONE, TO DESTROY ORGANIC COMPOUNDS IN GROUNDWATER. THE ULTRAVIOLET LIGHT REACTS WITH THE HYDROGEN PEROXIDE OR OZONE FORMING HYDROXYL RADICALS WHICH OXIDIZE ORGANIC COMPOUNDS. IN ADDITION, MANY

COMPOUNDS ABSORB ULTRAVIOLET LIGHT CAUSING THEM TO BE MORE REACTIVE TO CHEMICAL OXIDANTS. UV-OXIDATION WILL NOT PRODUCE TREATMENT RESIDUALS. THIS ALTERNATIVE WILL ONLY REQUIRE DISPOSAL OF CHEMICAL PRECIPITATION FILTER CAKE, IN ACCORDANCE WITH RCRA SUBTITLE C.

ALTERNATIVE T-4 HAS AN ESTIMATED CAPITAL COST OF \$1,377,000 AND OPERATION AND MAINTENANCE COSTS OF \$385,000. ITS PRESENT WORTH IS ESTIMATED AT \$7,357,000 FOR A 30-YEAR PERIOD AT A 5 PERCENT DISCOUNT RATE. ALTERNATIVE T-4 WILL REQUIRE APPROXIMATELY 18 TO 24 MONTHS TO IMPLEMENT.

3.3.6 ALTERNATIVE T-5 - CHEMICAL PRECIPITATION/ACTIVATED SLUDGE BIOLOGICAL TREATMENT/CARBON ADSORPTION

ALTERNATIVE T-5 CONSISTS OF CHEMICAL PRECIPITATION FOR REDUCTION OF INORGANIC CONTAMINANT CONCENTRATIONS AND ACTIVATED SLUDGE FOLLOWED BY CARBON ADSORPTION FOR REDUCTION OF ORGANIC CONTAMINANT CONCENTRATIONS. ACTIVATED SLUDGE IS A BIOLOGICAL TREATMENT PROCESS IN WHICH MICRO-ORGANISMS DESTROY ORGANIC COMPOUNDS IN GROUNDWATER BY CONSUMING THEM AS FOOD. RESIDUAL SLUDGE WILL BE DEWATERED IN A FILTER PRESS AND THE RESULTANT FILTER CAKE WILL BE PROPERLY DISPOSED IN ACCORDANCE WITH RCRA SUBTITLE C. CARBON ADSORPTION WILL THEN BE USED AS A FINAL POLISH TO TREAT ORGANIC COMPOUNDS WHICH ARE NOT READILY BIODEGRADABLE. THIS ALTERNATIVE WILL REQUIRE DISPOSAL (OR REGENERATION) OF CHEMICAL PRECIPITATION FILTER CAKE, ACTIVATED SLUDGE FILTER CAKE, AND SPENT CARBON.

ALTERNATIVE T-5 HAS AN ESTIMATED CAPITAL COST OF \$1,623,000 AND OPERATION AND MAINTENANCE COSTS OF \$311,000. ITS PRESENT WORTH IS ESTIMATED AT \$6,449,000 FOR A 30-YEAR PERIOD AT A 5 PERCENT DISCOUNT RATE. ALTERNATIVE T-5 WILL REQUIRE APPROXIMATELY 18 TO 24 MONTHS TO IMPLEMENT.

3.3.7 ALTERNATIVE T-6 - CHEMICAL PRECIPITATION/POWDERED ACTIVATED CARBON TREATMENT (PACT)

ALTERNATIVE T-6 CONSISTS OF CHEMICAL PRECIPITATION FOR REDUCTION OF INORGANIC CONTAMINANT CONCENTRATIONS AND PACT FOR REDUCTION OF ORGANIC CONTAMINANT CONCENTRATIONS. PACT IS A BIOLOGICAL TREATMENT PROCESS IN WHICH POWDERED ACTIVATED CARBON (PAC) IS ADDED DIRECTLY TO THE ACTIVATED SLUDGE REACTOR SO THAT BIODEGRADATION AND ADSORPTION OCCUR SIMULTANEOUSLY IN ONE VESSEL. THE PAC IS REMOVED IN THE CLARIFIER AND RECYCLED ALONG WITH THE ACTIVATED SLUDGE, THUS PROVIDING AN INCREASED RETENTION TIME FOR THOSE COMPOUNDS ADSORBED TO THE CARBON, ALLOWING FURTHER BIODEGRADATION. SPENT CARBON WILL BE EXPELLED ALONG WITH THE ACTIVATED SLUDGE. THIS ALTERNATIVE WILL REQUIRE DISPOSAL OF CHEMICAL PRECIPITATION FILTER CAKE AND ACTIVATED SLUDGE FILTER CAKE CONTAINING POWDERED ACTIVATED CARBON, IN ACCORDANCE WITH RCRA SUBTITLE C.

ALTERNATIVE T-6 HAS AN ESTIMATED CAPITAL COST OF \$1,551,000 AND OPERATION AND MAINTENANCE COSTS OF \$259,000. ITS PRESENT WORTH IS ESTIMATED AT \$5,582,000 FOR A 30-YEAR PERIOD AT A 5 PERCENT DISCOUNT RATE. ALTERNATIVE T-6 WILL REQUIRE APPROXIMATELY 18 TO 24 MONTHS TO IMPLEMENT.

#CAR

4.0 COOPERATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

THE GROUNDWATER EXTRACTION/DISCHARGE AND TREATMENT ALTERNATIVES DESCRIBED IN SECTIONS 3.2 AND 3.3 WERE EVALUATED AGAINST NINE SPECIFIED CRITERIA IN ACCORDANCE WITH CERCLA S 121(B), 42 USC S 9621(B), AND THE NCP, 40 CFR 300.430(E), TO SELECT AN OVERALL PREFERRED REMEDIAL ALTERNATIVE FOR INTERIM ACTION AT OLD O-FIELD. THE EXTRACTION/DISCHARGE ALTERNATIVES WERE EVALUATED SEPARATELY FROM THE TREATMENT ALTERNATIVES SO THAT A PREFERRED APPROACH FROM EACH OF THE TWO CATEGORIES COULD BE IDENTIFIED. THE OVERALL PREFERRED REMEDIAL ALTERNATIVE WAS THEN DEVELOPED BY COMBINING THE PREFERRED EXTRACTION/DISCHARGE ALTERNATIVE WITH THE PREFERRED TREATMENT ALTERNATIVE.

THIS SECTION DISCUSSES THE EVALUATION OF THE EXTRACTION/DISCHARGE AND TREATMENT ALTERNATIVES AGAINST THE SPECIFIED CRITERIA. AQUIFER PUMPING TESTS AND GROUNDWATER TREATABILITY STUDIES WERE CONDUCTED TO OBTAIN IMPORTANT INFORMATION REQUIRED TO MAKE AN INFORMED EVALUATION.

4.1 EVALUATION CRITERIA

THE FOLLOWING EVALUATION CRITERIA WERE USED IN THE COMPARATIVE ANALYSIS OF ALTERNATIVES AND ARE BASED ON SECTION 121(B) OF CERCLA, 42 USC S 9621(B), AND THE NCP, 40 CFR 300.430(E):

1. OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT ADDRESSES WHETHER OR NOT A REMEDY PROVIDES ADEQUATE PROTECTION AND DESCRIBES HOW RISKS POSED THROUGH EACH PATHWAY ARE ELIMINATED, REDUCED, OR CONTROLLED THROUGH TREATMENT, ENGINEERING CONTROLS, OR INSTITUTIONAL CONTROLS.
2. COMPLIANCE WITH ARARS ADDRESSES WHETHER OR NOT A REMEDY WILL MEET ALL OF THE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS OF FEDERAL AND STATE ENVIRONMENTAL STATUTES AND/OR PROVIDE GROUNDS FOR INVOKING A WAIVER.
3. LONG-TERM EFFECTIVENESS AND PERMANENCE REFERS TO THE MAGNITUDE OF RESIDUAL RISK AND THE ABILITY OF A REMEDY TO MAINTAIN RELIABLE PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT OVER TIME ONCE CLEANUP GOALS HAVE BEEN MET.
4. REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT IS THE ANTICIPATED PERFORMANCE OF TREATMENT TECHNOLOGIES THAT MAY BE EMPLOYED IN A REMEDY.
5. SHORT-TERM EFFECTIVENESS REFERS TO THE SPEED WITH WHICH THE REMEDY ACHIEVES PROTECTION, AS WELL AS THE REMEDY'S POTENTIAL TO CREATE ADVERSE IMPACTS ON HUMAN HEALTH AND THE ENVIRONMENT THAT MAY RESULT DURING THE CONSTRUCTION AND IMPLEMENTATION PERIOD.
6. IMPLEMENTABILITY IS THE TECHNICAL AND ADMINISTRATIVE FEASIBILITY OF A REMEDY, INCLUDING THE AVAILABILITY OF MATERIALS AND SERVICES NEEDED TO IMPLEMENT THE CHOSEN SOLUTION.
7. COST INCLUDES CAPITAL AND OPERATION AND MAINTENANCE COSTS, AND PRESENT WORTH. ALL OF THE REMEDIAL ALTERNATIVES WILL OPERATE UNTIL THE FINAL REMEDY FOR ALL OPERABLE UNITS FOR OLD O-FIELD IS DETERMINED. AN OPERATING PERIOD OF 30 YEARS WAS SELECTED TO ALLOW FOR COMPARISON OF ALTERNATIVES. ALTHOUGH NOT INCLUDED IN THE COST ESTIMATES, EQUIPMENT SUCH AS WELLS, MULTI-LAYER CAPS, AND TREATMENT UNITS WILL LIKELY REQUIRE REPLACEMENT AFTER 20 TO 30 YEARS OF OPERATION OR LESS.
8. STATE ACCEPTANCE INDICATES WHETHER, BASED ON ITS REVIEW OF THE FFS AND PROPOSED PLAN, THE STATE CONCURS WITH, OPPOSES, OR HAS NO COMMENT ON THE PREFERRED ALTERNATIVE; AND
9. COMMUNITY ACCEPTANCE INDICATES THE PUBLIC SUPPORT OF A GIVEN REMEDY AND IS DISCUSSED IN THE RESPONSIVENESS SUMMARY PROVIDED IN APPENDIX A.

THE FIRST TWO CRITERIA RELATE TO STATUTORY REQUIREMENTS AND ARE, THEREFORE, CATEGORIZED AS THRESHOLD CRITERIA THAT MUST BE SATISFIED BY THE ALTERNATIVE. THE NEXT FIVE CRITERIA ARE GROUPED TOGETHER AS PRIMARY BALANCING CRITERIA UPON WHICH THE ANALYSIS WAS BASED. THE FINAL TWO CRITERIA WERE ADDRESSED FOLLOWING COMMENT ON THE PROPOSED PLAN AND ARE CONSIDERED MODIFYING CRITERIA.

4.2 EVALUATION OF GROUNDWATER EXTRACTION/DISCHARGE ALTERNATIVES

4.2.1 AQUIFER PUMPING TESTS

GROUNDWATER EXTRACTION/DISCHARGE ALTERNATIVES WERE DEVELOPED AND EVALUATED IN THE FFS FOR GROUNDWATER REMEDIATION AT OLD O-FIELD BASED ON HYDROGEOLOGIC AND CONTAMINANT DATA GENERATED BY THE HGA. A USGS GROUNDWATER FLOW MODEL (MODFLOW) WAS USED TO DEVELOP AND OPTIMIZE EXTRACTION WELL NETWORKS UNDER SEVERAL SCENARIOS FOR THE SITE, AND TO COMPARE THE EFFECTIVENESS, IMPLEMENTABILITY, AND COST OF EACH ALTERNATIVE. HOWEVER, SIGNIFICANT UNCERTAINTY WAS FOUND TO EXIST IN PREDICTING EXTRACTION SYSTEM PERFORMANCE BASED ON GROUNDWATER MODELING RESULTS. SPECIFICALLY, THE RESPONSE OF THE OLD O-FIELD AQUIFER SYSTEMS TO PUMPING (I.E., STRESSED CONDITIONS) WAS NOT KNOWN, AND DATA WERE LACKING WITH REGARD TO: 1) CAPTURE ZONE SIZES FOR INDIVIDUAL WELLS AND THE OVERALL EXTRACTION NETWORK; 2) INTERACTIONS BETWEEN WATSON CREEK AND THE AQUIFER SYSTEM (I.E., THE EXTENT OF INDUCED INFILTRATION); AND 3) THE EFFECTS OF PUMPING ON VERTICAL GRADIENTS AND LEAKAGE RATES BETWEEN THE WATER-TABLE AND UPPER CONFINED AQUIFERS. ALSO, THE ASSUMPTION THAT EXISTING MONITORING WELLS COULD BE INCORPORATED INTO THE EXTRACTION SYSTEM (A SIGNIFICANT COST FACTOR) REQUIRED VERIFICATION THROUGH ACTUAL TESTING.

BASED ON THESE CONSIDERATIONS, AN AQUIFER TESTING PROGRAM WAS IMPLEMENTED, CONSISTING OF STEP-DRAWDOWN TESTS

AND CONSTANT-DISCHARGE TESTS ON THREE EXISTING MONITORING WELLS IN THE CONTAMINATED PLUME AREA. EXISTING MONITORING WELLS WERE USED IN THIS PROGRAM TO DETERMINE WHETHER THESE WELLS COULD BE INCORPORATED INTO A FULL-SCALE EXTRACTION WELL NETWORK; AND BECAUSE LOGISTICAL DIFFICULTIES (I.E., REMOTE DRILLING) ASSOCIATED WITH INSTALLATION OF EXTRACTION TEST WELLS WOULD CAUSE SCHEDULE DELAYS OF AT LEAST ONE YEAR BEFORE ANY TYPE OF AQUIFER TESTING PROGRAM COULD BE IMPLEMENTED.

HOWEVER, STEP-DRAWDOWN TESTING INDICATED THAT SEVERAL OF THE WELLS SELECTED FOR TESTING WOULD NOT SUSTAIN LONG-TERM PUMPING AT EXTRACTION RATES SUFFICIENT TO ADEQUATELY STRESS THE AQUIFER SYSTEM. BECAUSE THE LOW-YIELD WELLS ARE LOCATED IN WHAT WOULD APPEAR TO BE HIGH-PERMEABILITY AREAS (BASED ON HGA DATA), IT APPEARS THAT THE OBSERVED YIELDS ARE ALMOST CERTAINLY A FUNCTION OF WELL INEFFICIENCIES. WELL INEFFICIENCIES ARE MOST LIKELY THE RESULT OF SHORT SCREEN LENGTHS, SMALL SCREEN SLOT SIZES, AND THE USE OF FINE-GRAINED FILTER PACK MATERIALS. THEREFORE, LONG-TERM CONSTANT-DISCHARGE TESTS FOR LOW-YIELD WELLS WERE CANCELED BASED ON THE LIMITED ADDITIONAL DATA THAT THEY WOULD PROVIDE.

ADDITIONAL INFORMATION ON AQUIFER PROPERTIES AND BOUNDARY CONDITIONS IN THE AFFECTED AREAS OF OLD O-FIELD WILL BE GATHERED BY TESTING EXTRACTION WELLS INSTALLED DURING AN EARLY PERIOD OF THE DESIGN/CONSTRUCTION PHASE OF THE REMEDIATION EFFORT. SUITABLY DESIGNED EXTRACTION WELLS, MADE AVAILABLE BY IMPLEMENTATION OF THE PROPOSED INTERIM REMEDY, WILL PROVIDE DATA NEEDED FOR EVALUATING THE PERFORMANCE OF LONG-TERM OR PERMANENT REMEDIES. ANALYSIS OF GROUNDWATER FROM THESE WELLS ALSO WILL PROVIDE DATA FOR DESIGN OF THE TREATMENT SYSTEM, AND THE PERFORMANCE PARAMETERS THAT WILL NEED TO BE MONITORED.

DESPITE THE FACT THAT AQUIFER TESTS AT OLD O-FIELD WERE UNABLE TO PROCEED AS INITIALLY PLANNED, THE MODIFIED PROGRAM PROVIDED IMPORTANT INFORMATION TO SUPPORT THE SELECTION OF THE PREFERRED EXTRACTION/ DISCHARGE ALTERNATIVE, AND PROVIDED ESSENTIAL DATA FOR REFINEMENT OF GROUNDWATER MODELING EFFORTS AND PRELIMINARY DESIGN OF GROUNDWATER EXTRACTION ALTERNATIVES. MORE DETAILED DISCUSSION OF RELEVANT DATA CAN BE FOUND IN THE AQUIFER TESTING REPORT. IMPORTANT FINDINGS CONCERNING THE AQUIFER PROPERTIES AND CHARACTER ARE SUMMARIZED AS FOLLOWS:

- * LEAKAGE THROUGH THE CLAY LAYER BETWEEN THE WATER-TABLE AQUIFER (WTA) AND THE UPPER CONFINED AQUIFER (UCA) OCCURS ALMOST INSTANTANEOUSLY AS EVIDENCED BY EARLY-TIME DRAWDOWN IN THE WTA (WITH PUMPING IN THE UCA). THIS VERIFIES THE ASSUMED HYDRAULIC CONNECTION BETWEEN THE TWO SHALLOW AQUIFERS, AND SUGGESTS THAT SINGLE EXTRACTION WELLS SCREENED IN BOTH AQUIFERS MAY BE PREFERABLE TO EXTRACTION WELL PAIRS.
- * THE SEMI-CONFINING UNIT IS Laterally EXTENSIVE IN THE CONTAMINATED PLUME AREA NORTHEAST OF THE OLD O-FIELD LANDFILL, AS EVIDENCED BY EARLY-TIME DRAWDOWN IN WELLS SCREENED IN THE UCA AT THESE LOCATIONS. EARLY DRAWDOWN OBSERVED IN MONITORING WELLS SEVERAL FEET AWAY FROM THE PUMPING WELL INDICATE THAT THE AQUIFER IS UNDER CONFINING PRESSURES.
- * TIDAL CHANGES OBSERVED IN WATSON CREEK ARE RESPONSIBLE FOR WATER-LEVEL CHANGES IN MONITORING WELLS IN THE WATER TABLE, UPPER CONFINED, AND LOWER CONFINED AQUIFERS. WATER-LEVEL CHANGES IN WELLS DUE TO TIDAL INFLUENCES ARE ROUGHLY HALF THE AMPLITUDE OF THE TIDES OBSERVED IN WATSON CREEK.
- * EXISTING MONITORING WELLS ARE NOT APPROPRIATE FOR GROUNDWATER EXTRACTION AS MAXIMUM ATTAINABLE YIELDS IN THESE WELLS ARE NOT REPRESENTATIVE OF AQUIFER MATERIALS. THIS FACTOR, AS PREVIOUSLY NOTED, APPEARS TO BE RELATED TO WELL INEFFICIENCY RATHER THAN MISINTERPRETATION OF AQUIFER HYDRAULIC PROPERTIES.

THE ABOVE FINDINGS PROVIDE ADDITIONAL DATA FOR ANALYSIS OF THE EXTRACTION/DISCHARGE ALTERNATIVES DEVELOPED IN THE FOCUSED FS, AND SUPPORT THE SELECTION OF THE PREFERRED ALTERNATIVE. THE SHALLOW AQUIFER SYSTEM PRESENT AT THE SITE, INCLUDING THE WATER-TABLE AQUIFER AND THE UPPER CONFINED AQUIFER, RESPONDS TO PUMPING STRESSES AS A SINGLE, SEMI-CONFINED, OR LEAKY AQUIFER. THE INTERCONNECTED NATURE OF THESE AQUIFERS PERMITS THE DESIGN OF A GROUNDWATER EXTRACTION SYSTEM THAT RETRIEVES WATER FROM BOTH HORIZONS, THEREBY MINIMIZING DRAWDOWN AND MAXIMIZING THE AREA OF INFLUENCE FOR EACH EXTRACTION WELL. THIS ALLOWS FOR THE INSTALLATION OF THE FEWEST NUMBER OF WELLS NECESSARY TO CAPTURE CONTAMINANTS EMANATING FROM THE FENCED AREA AT OLD O-FIELD. HOWEVER, AS PREVIOUSLY NOTED, ADDITIONAL TESTING (DURING THE EARLY STAGES OF EXTRACTION SYSTEM DESIGN/CONSTRUCTION) WILL BE REQUIRED TO DETERMINE THE EXACT NUMBER AND LOCATION OF EXTRACTION WELLS REQUIRED FOR THE PREFERRED ALTERNATIVE, AND TO PROVIDE DETAILED INFORMATION NEEDED TO COMPLETE THE EXTRACTION SYSTEM DESIGN SUCH THAT ALL CONTAMINANT PLUMES EMANATING FROM THE WASTE ARE CAPTURED TO THE MAXIMUM EXTENT POSSIBLE. BECAUSE OF THE UNCERTAINTIES, STRINGENT PERFORMANCE MONITORING WILL BE REQUIRED DURING THE INTERIM REMEDY TO ENSURE PLUME CONTAINMENT. IF MONITORING INDICATES PLUME CONTAINMENT IS NOT ACHIEVED, THE EXTRACTION SYSTEM WILL BE MODIFIED TO ACCOMPLISH THIS.

4.2.2 GROUNDWATER EXTRACTION/DISCHARGE ALTERNATIVES EVALUATION

GROUNDWATER EXTRACTION/DISCHARGE ALTERNATIVES ARE EVALUATED.

BELOW WITH RESPECT TO THE NINE CRITERIA SPECIFIED IN SECTION 4.1. A SUMMARY OF THE EVALUATION RESULTS IS PRESENTED IN TABLE 8.

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT. ALL OF THE ALTERNATIVES WOULD PROVIDE ADEQUATE PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT BY PROTECTING NEARBY ECOSYSTEMS, MINIMIZING THE POTENTIAL FOR HUMAN EXPOSURE TO CONTAMINANTS" AND PREVENTING OFF-SITE MIGRATION OF HAZARDOUS SUBSTANCES VIA GROUNDWATER PATHWAYS. EACH EXTRACTION/DISCHARGE ALTERNATIVE CONSIDERED WOULD MINIMIZE ENVIRONMENTAL RISKS TO SENSITIVE AQUATIC AND TERRESTRIAL ECOSYSTEMS IN WATSON CREEK, GUNPOWDER RIVER, AND THE SURROUNDING WETLANDS BY PREVENTING DISCHARGE OF CONTAMINATED GROUNDWATER TO THESE AREAS. THE EXTRACTION/DISCHARGE ALTERNATIVES WOULD ALSO CONTROL POTENTIAL HUMAN HEALTH RISKS ASSOCIATED WITH DIRECT CONTACT, FOOD-CHAIN, SURFACE WATER, AND GROUNDWATER EXPOSURES THAT COULD RESULT FROM GROUNDWATER CONTAMINATION AT THE SITE.

THE CAPPING OF THE LANDFILL AREA AND THE GROUNDWATER LEVEL CONTROL INCLUDED IN ALTERNATIVE E-4 OFFERS ADDITIONAL HUMAN HEALTH AND ENVIRONMENTAL BENEFITS: 1) IT EFFECTIVELY CONTROLS AIR EMISSIONS FROM THE DISPOSAL SITE, INCLUDING DIRECT VOLATILE EMISSIONS AND AIRBORNE TRANSPORT OF CONTAMINATED DUST PARTICLES; AND 2) IT ISOLATES WASTES BENEATH THE CAP AND MINIMIZES DIRECT CONTACT BETWEEN THE WASTES AND THE GROUNDWATER. HOWEVER, THE EXTREME POTENTIAL SAFETY PROBLEMS ASSOCIATED WITH ANY DIRECT-INTRUSION REMEDIES SUCH AS CAPPING WILL NEED TO BE ADDRESSED BEFORE THIS ALTERNATIVE COULD BE IMPLEMENTED.

ALTERNATIVE E-5 MAY BE MORE PROTECTIVE THAN SOME OF THE OTHER ALTERNATIVES BECAUSE ADDITIONAL CONTAMINATION IS TRAPPED BY THE EXTRACTION SYSTEM WITHIN THE IMMEDIATE VICINITY OF THE LANDFILL, RATHER THAN AS IT MIGRATES DOWNGRAIENT TOWARD POTENTIAL DISCHARGE POINTS. HOWEVER, UNCERTAINTY REGARDING THE CHEMICAL QUALITY AND TREATABILITY OF EXTRACTED GROUNDWATER FOLLOWING SOURCE FLUSHING IS A SIGNIFICANT POTENTIAL DISADVANTAGE FOR THIS ALTERNATIVE IN PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT. SYSTEM FAILURE COULD RESULT IN EXTENSIVE FLUSHING OF CONTAMINANTS INTO PREVIOUSLY UNCONTAMINATED ZONES OF THE AQUIFERS, AND GREATLY INCREASED MASS LOADING TO WATSON CREEK, POSSIBLY WITH TOXIC EFFECTS. THIS ALTERNATIVE HAS TOO MANY AREAS OF UNCERTAINTY TO BE RATED AS FULLY PROTECTIVE OF HUMAN HEALTH AND THE ENVIRONMENT.

THE EFFECTIVENESS OF ALTERNATIVE E-6 IS DIFFICULT TO DEMONSTRATE IN THE FIELD DUE TO THE HIGHLY COMPLEX NATURE OF THE ALTERNATIVE. HOWEVER, EVEN IF SOME SYSTEM FAILURE DOES OCCUR, IT WILL NOT HAVE THE POTENTIALLY SEVERE CONSEQUENCES THAT ARE ASSOCIATED WITH ALTERNATIVE E-5.

COMPLIANCE WITH ARARS.

GROUNDWATER EXTRACTION/DISCHARGE ALTERNATIVES WILL COMPLY WITH CHEMICAL-SPECIFIC ARARS IF ACCOMPANIED BY TREATMENT OF EXTRACTED WATER. ATTAINMENT OF GROUNDWATER DISCHARGE LIMITATIONS FOR DISCHARGE TO GUNPOWDER RIVER, WATSON CREEK, AND/OR RE-INJECTION IS ADDRESSED UNDER GROUNDWATER TREATMENT ALTERNATIVES. EXTRACTION AND TREATMENT OF GROUNDWATER MAY EVENTUALLY RESULT IN ATTAINMENT OF GROUNDWATER REMEDIATION IN THE

WATER-TABLE AND UPPER CONFINED AQUIFERS AT THE SITE; HOWEVER, A VERY CONSIDERABLE TIME PERIOD MAY BE REQUIRED TO REACH THESE CONDITIONS BECAUSE OF THE CONTINUED EXISTENCE OF AN ACTIVE CONTAMINATION SOURCE. ALTERNATIVE E-4 MAY ACHIEVE GROUNDWATER STANDARDS MORE RAPIDLY BECAUSE THE WASTE IS ISOLATED; HOWEVER, SUCH ATTAINMENT MAY BE TEMPORARY OR INTERMITTENT AS ADDITIONAL CONTAMINANTS ARE LEACHED FROM THE SOURCE. ALTERNATIVE E-5 INITIALLY WILL RESULT IN INCREASED LEVELS OF CONTAMINANT CONCENTRATIONS; HOWEVER, THIS MORE HIGHLY CONTAMINATED WATER WILL BE CAPTURED BY THE EXTRACTION SYSTEM AND TREATED TO MEET DISCHARGE STANDARDS BEFORE RELEASE TO SURFACE WATER OR RE-APPLICATION TO THE FIELD. THE FLUSHING ACTION PROVIDED BY THE RE-INJECTION OF TREATED WATER BACK INTO THE AQUIFER UNDER ALTERNATIVE E-6 WILL AID IN THE ATTAINMENT OF GROUNDWATER REMEDIATION, BUT WILL NOT IMPROVE PERFORMANCE OF THE CONTAINMENT OBJECTIVE.

LOCATION-SPECIFIC AND ACTION-SPECIFIC ARARS THAT APPLY TO GROUNDWATER EXTRACTION ARE: 1) OBTAINING THE NECESSARY PERMITS AND/OR COMPLYING WITH THEIR SUBSTANTIVE REQUIREMENTS; AND 2) AVOIDING RESOURCE DAMAGE THAT COULD POTENTIALLY BE CAUSED BY GROUNDWATER PUMPING, SUCH AS WETLANDS DEWATERING. THE MULTI-LAYER CAP INCLUDED IN ALTERNATIVE E-4 WILL COMPLY WITH RCRA CLOSURE REQUIREMENTS FOR LANDFILLS. ALL ALTERNATIVES ARE EXPECTED TO MEET LOCATION AND ACTION-SPECIFIC ARARS, INCLUDING PROTECTION OF NEARBY WETLANDS AND SATISFYING TREATED WATER STANDARDS ESTABLISHED FOR SURFACE WATER DISCHARGE AND RE-INJECTION.

LONG-TERM EFFECTIVENESS AND PERMANENCE.

ASSUMING THAT THE EXTRACTION SYSTEMS ARE OPTIMIZED AND ADEQUATE FLOW RATES CAN BE MAINTAINED TO PROVIDE THE NECESSARY CAPTURE OF THE CONTAMINATED GROUNDWATER PLUME THAT IS CURRENTLY DISCHARGING TO WATSON CREEK THROUGH THE WATER-TABLE AND UPPER CONFINED AQUIFERS, IT IS HIGHLY LIKELY ALL THE ALTERNATIVES WILL BE EFFECTIVE IN MEETING REMEDIAL ACTION OBJECTIVES. AQUIFER REMEDIATION MAY NEVER BE ACCOMPLISHED, HOWEVER, IF AN ACTIVE CONTAMINATION SOURCE REMAINS IN PLACE AT OLD O-FIELD. THEREFORE, ANY GROUNDWATER EXTRACTION ALTERNATIVE THAT IS IMPLEMENTED AT THE FIELD MUST OPERATE FOR AN INDEFINITE (BUT PROBABLY VERY LONG) TIME PERIOD AND, TO SOME EXTENT, MUST BE CONSIDERED A MAINTENANCE ACTION.

THE WASTE ISOLATION AFFORDED BY THE CAP INCLUDED IN ALTERNATIVE E-4 WILL RESTRICT GROUNDWATER CONTAMINATION BY PROVIDING LONG-TERM REDUCTIONS IN THE AMOUNT OF WATER THAT OTHERWISE WOULD PASS THROUGH THE CONTAMINATED SOILS, THUS REDUCING THE GENERATION OF CONTAMINATED LEACHATE THAT COULD MIGRATE TO GROUNDWATER. HOWEVER, THE CAP WILL NOT PREVENT LIQUID WASTES FROM MIGRATING TO THE GROUNDWATER BY GRAVITY ALTHOUGH IT WILL SLOW THE MIGRATION PROCESS. THE LONGEVITY AND MAINTENANCE REQUIREMENTS OF THE MULTI-LAYER CAP WILL AFFECT THE LONG-TERM EFFECTIVENESS OF ALTERNATIVE E-4. AFTER APPROXIMATELY 30 YEARS, REPLACEMENT OF THE CAP MAY BE NECESSARY DUE TO WEATHERING AND EROSION. THE LONG-TERM EFFECTIVENESS OF ALTERNATIVE E-4 MAY BE NO BETTER THAN THE MORE SIMPLE AND LESS COSTLY ALTERNATIVE E-1; HOWEVER, SHORT-TERM BENEFITS WITH REGARD TO GROUNDWATER QUALITY MAY BE SIGNIFICANT AND ALTERNATIVE E-4 MAY BE VALUABLE AS AN INTERIM ACTION THAT WILL ADDRESS MAJOR SITE PROBLEMS (I.E., POTENTIAL FOR DIRECT CONTACT WITH DISPOSED MATERIALS) UNTIL AN ACTIVE SOURCE (OU TWO) REMEDIATION STRATEGY CAN BE IMPLEMENTED.

A POTENTIAL ADVANTAGE FOR ALTERNATIVE E-5 IS THAT THE EXTRACTION/SOURCE FLUSHING SEQUENCE RESULTS IN A HYDRAULIC GRADIENT PATTERN THAT CAUSES RADIAL GROUNDWATER FLOW OUTWARD FROM THE CENTER OF THE LANDFILL WHICH RESULTS IN CAPTURE VERY NEAR THE SITE AND, THEREFORE, VERY SHORT MIGRATION PATHWAYS; THEREBY MINIMIZING ADDITIONAL CONTAMINATION OF DOWNGRAIENT ZONES OF THE AQUIFERS. HOWEVER, THE DISADVANTAGES ASSOCIATED WITH ALTERNATIVE E-5 ARE LIKELY TO OUTWEIGH ANY POTENTIAL ADVANTAGES. THESE DISADVANTAGES ARE: 1) EXTRACTED WATER QUALITY IS DIFFICULT TO PREDICT AND MAY BE QUITE POOR AND VARIABLE MAKING TREATMENT MORE DIFFICULT THAN FOR OTHER ALTERNATIVES; 2) EFFECTIVENESS OF SOURCE FLUSHING IN ACHIEVING SOURCE REMEDIATION IS IMPOSSIBLE TO PREDICT AND VERY DIFFICULT TO MONITOR BECAUSE OF THE UNKNOWN CHARACTERISTICS OF THE SOURCE; AND 3) PROBLEMS WITH RE-INFILTRATION THROUGH THE SURFACE OF THE FIELD ARE POSSIBLE OVER THE LONG TERM, AND MAY BE DIFFICULT TO SOLVE DUE TO UNEXPLODED ORDNANCE AND CHEMICAL AGENT HAZARDS ASSOCIATED WITH ON-SITE ACTIVITIES; AND 4) GROUNDWATER MOUNDING BENEATH THE DISPOSAL SITE CAUSED BY INCREASED RECHARGE MAY RESULT IN CONTAMINANT MIGRATION INTO PREVIOUSLY UNCONTAMINATED ZONES OF THE AQUIFER. DESPITE THESE DISADVANTAGES, ALTERNATIVE E-5 IS THE ONLY ALTERNATIVE THAT PROVIDES ANY POTENTIAL FOR ACTIVE SOURCE REMEDIATION AND, THEREFORE, HOLDS A MAJOR ADVANTAGE OVER ALL OTHER REMEDIES IN PROVIDING A PERMANENT SOLUTION TO SITE PROBLEMS.

POTENTIAL LONG-TERM EFFECTIVENESS CONCERNS SPECIFIC TO ALTERNATIVE E-6 INCLUDE: 1) PERFORMANCE MONITORING AND EFFECTIVENESS DEMONSTRATION OF THIS COMPLEX SYSTEM MAY NOT BE POSSIBLE; 2) OPERATIONAL PROBLEMS THAT MAY OCCUR WITH RE-INJECTION WELLS, INCLUDING SCREEN CLOGGING, AIRLOCKS, AND METAL PRECIPITATION; AND 3) POSSIBLE

CHANGES IN THE PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE AQUIFERS (E.G., IRON/MANGANESE PRECIPITATION) THAT MAY RESULT FROM RE-INJECTION OF TREATED WATER COULD AFFECT THE OVERALL PERFORMANCE OF THE EXTRACTION SYSTEM. BASED ON THESE FACTORS, LONG-TERM EFFECTIVENESS OF ALTERNATIVE E-6 IS CONSIDERED QUESTIONABLE.

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT.

GROUNDWATER EXTRACTION AT OLD O-FIELD DOES NOT DIRECTLY AFFECT TOXICITY OR VOLUME OF CONTAMINANTS CONTAINED IN THE GROUNDWATER, BUT RATHER REMOVES CONTAMINATION FROM THE AQUIFERS SO THAT TREATMENT CAN BE PERFORMED. ALTERNATIVE E-4 WILL REDUCE THE MOBILITY OF WASTES WITHIN THE SOURCE AREA BY LIMITING THE DEVELOPMENT OF LEACHATE AND THE DISSOLUTION OF WASTES BY DIRECT CONTACT WITH GROUNDWATER. ALTERNATIVE E-5 WILL INITIALLY INCREASE THE MOBILITY OF WASTES CONTAINED WITHIN THE LANDFILL; HOWEVER, THESE CONTAMINANTS WILL BE CAPTURED BY THE EXTRACTION SYSTEM IN CLOSE PROXIMITY TO THE LANDFILL.

ALTERNATIVE E-6 LIMITS THE MOBILITY OF WASTES MIGRATING TO WARD WATSON CREEK BY CREATING A HYDROLOGIC BARRIER AND CONTAINING CONTAMINATION TO A SMALL PORTION OF THE AQUIFER NEAR THE SOURCE AREA. ALTERNATIVE E-6 ALSO IS VERY EFFECTIVE IN PREVENTING OFF-SITE MIGRATION IN THE UPPER CONFINED AQUIFER, REVERSING HYDRAULIC GRADIENTS TO PROVIDE MORE EFFECTIVE CAPTURE, AND MINIMIZING INDIRECT INFILTRATION FROM WATSON CREEK. VERTICAL GRADIENT REVERSAL CAUSED BY THE RE-INJECTION OF TREATED GROUNDWATER INTO THE UPPER CONFINED AQUIFER PREVENTS MIGRATION OF CONTAMINANTS FROM THE WATER-TABLE AQUIFER INTO THE UPPER CONFINED AQUIFER.

SHORT-TERM EFFECTIVENESS.

ALTERNATIVE E-1 INVOLVES INSTALLATION OF THE FEWEST NUMBER OF NEW EXTRACTION WELLS. REMOTE-DRILLING WILL BE REQUIRED FOR WELL INSTALLATION AND EXTENSIVE HEALTH AND SAFETY PRECAUTIONS WILL BE NECESSARY, AND SOPS FOR THESE ACTIVITIES WILL NEED TO BE DEVELOPED. HEALTH AND SAFETY CONCERNS AND LOGISTICAL PROBLEMS ASSOCIATED WITH START-UP OF THE EXTRACTION SYSTEMS ARE NOT NEGLIGIBLE, BUT MAJOR DELAYS OR GREATLY INCREASED COSTS DO NOT APPEAR TO BE LIKELY. UNCERTAINTIES ALSO EXIST BECAUSE THE TREATABILITY OF THE GROUNDWATER WITHDRAWN IN AN IMPROVED WELL DESIGN IS NOT KNOWN PRECISELY.

DISCHARGE OF TREATED GROUNDWATER TO THE GUNPOWDER RIVER OR THE OLD O-FIELD AQUIFER SYSTEM WILL REQUIRE MEETING THE SUBSTANTIVE REQUIREMENTS OF NPDES AND/OR RE-INJECTION PERMITS FOR ALL OF THE EXTRACTION/DISCHARGE ALTERNATIVES. DISCHARGE REQUIREMENTS MAY BE VERY STRINGENT AND MAY BE DIFFICULT TO ESTABLISH BECAUSE OF THE CONCERN REGARDING POTENTIAL IMPACTS TO THE SENSITIVE UPPER CHESAPEAKE BAY AREA.

SEVERAL MAJOR LOGISTICAL AND HEALTH AND SAFETY PROBLEMS WILL NEED TO BE ADDRESSED PRIOR TO IMPLEMENTATION OF ALTERNATIVE E-4, WHICH MAY CAUSE DELAYS AND LIMIT SHORT-TERM EFFECTIVENESS OF THIS ALTERNATIVE, INCLUDING: 1) DETAILED DEVELOPMENT OF AN APPROACH FOR INSTALLATION OF THE CAP OVER THE LANDFILL; AND 2) INSTALLATION OF CIRCUMFERENTIAL WELLS IN VERY CLOSE PROXIMITY TO SUSPECTED DISPOSAL AREAS. CAPPING OLD O-FIELD HAS THE POTENTIAL TO BE AN EXTREMELY HAZARDOUS ACTIVITY DUE TO THE PRESENCE OF UNEXPLODED ORDNANCE AND CHEMICAL WARFARE AGENTS IN THE DISPOSAL AREA.

IMPLEMENTATION OF ALTERNATIVE E-5 MAY INVOLVE SEVERAL SHORT-TERM PROBLEMS AS SOME RESEARCH AND DEVELOPMENT (E.G., PILOT-SCALE FIELD TESTS ON A SMALL PORTION OF THE SITE) MAY BE REQUIRED DUE TO CONSIDERABLE UNCERTAINTY THAT EXISTS REGARDING ITS PERFORMANCE. MORE INFORMATION ON THE EXPECTED CHEMICAL QUALITY OF THE EXTRACTED GROUNDWATER IS NECESSARY TO ENSURE THAT DISCHARGE LIMITS FROM THE TREATMENT SYSTEM ARE NOT EXCEEDED.

IMPLEMENTATION OF ALTERNATIVE E-6 MAY BE RESTRICTED BY THE INABILITY TO DEVELOP A PERFORMANCE MONITORING SYSTEM AND PROGRAM TO BE UTILIZED IN THE FIELD.

IMPLEMENTABILITY.

ALTERNATIVE E-1 IS THE MOST SIMPLE, STRAIGHTFORWARD ALTERNATIVE UNDER CONSIDERATION.

THE IMPLEMENTABILITY OF ALTERNATIVE E-4 IS LIMITED BY HEALTH AND SAFETY HAZARDS ASSOCIATED WITH INSTALLATION OF THE CAP WHICH INVOLVES WORKING WITHIN THE BOUNDARIES OF OLD O-FIELD. EXTENSIVE SAFETY REVIEW WILL BE REQUIRED PRIOR TO CONSTRUCTION. IN ADDITION, SOME OF THE LOCATIONS FOR INSTALLATION OF CIRCUMFERENTIAL

WELLS, UTILIZED BY ALTERNATIVES E-4, E-5, AND E-6, ARE IN VERY CLOSE PROXIMITY TO THE DISPOSAL SITE BOUNDARIES, AND WILL REQUIRE SPECIAL CAUTION DURING DRILLING AND INSTALLATION ACTIVITIES, AND POSSIBLY MORE EXTENSIVE GEOPHYSICAL CHARACTERIZATIONS PRIOR TO DRILLING.

FOR ALTERNATIVE E-5, A SPRAY IRRIGATION NETWORK WOULD BE REQUIRED TO BE INSTALLED WITHIN THE SOURCE AREA BOUNDARIES, WHERE WORK IS GREATLY RESTRICTED BY ORDNANCE AND CHEMICAL AGENT HAZARDS; HOWEVER, INSTALLATION AND MAINTENANCE CAN PROBABLY BE ACHIEVED BY USE OF REMOTE EQUIPMENT AND SURFACE SWEEPS BY EXPLOSIVE ORDNANCE DISPOSAL EXPERTS TO CLEAR "WORK PATHWAYS". IMPLEMENTATION, HOWEVER, WILL BE DIFFICULT BECAUSE OF THE SAFETY HAZARDS ASSOCIATED WITH OLD O-FIELD.

THE GREATEST DIFFICULTY WITH ALTERNATIVE E-6 IS DEVELOPING A WORKABLE APPROACH TO DEMONSTRATING THE SYSTEM'S EFFECTIVENESS IN THE FIELD AND MONITORING ITS PERFORMANCE.

COST.

THE PRESENT WORTH OF ALTERNATIVE E-1 IS \$1,763,000 FOR A 30-YEAR PERIOD AT A 5 PERCENT DISCOUNT RATE. ALTERNATIVE E-6 HAS A PRESENT WORTH OF \$3,004,000. ALTERNATIVE E-5 AND E-4 HAVE PRESENT WORTH OF \$3,027,000 AND \$4,078,000, RESPECTIVELY.

STATE ACCEPTANCE.

THE STATE OF MARYLAND CONCURS WITH THE SELECTED EXTRACTION/DISCHARGE ALTERNATIVE INDICATED IN THE DECLARATION AND IN SECTION 5.0.

COMMUNITY ACCEPTANCE.

AS MENTIONED IN SECTION 1.4, THE PUBLIC WAS INVITED TO REVIEW THE ADMINISTRATIVE RECORD, ATTEND A PUBLIC MEETING, AND SUBMIT COMMENTS ON ALL EXTRACTION/DISCHARGE ALTERNATIVES UNDER CONSIDERATION. THE RESPONSIVENESS SUMMARY PROVIDED IN APPENDIX A GIVES A THOROUGH REVIEW OF PUBLIC COMMENTS AS WELL AS ARMY AND EPA RESPONSES. COMMUNITY ACCEPTANCE IS ASSESSED IN DETAIL IN THE RESPONSIVENESS SUMMARY.

4.3 EVALUATION OF GROUNDWATER TREATMENT ALTERNATIVES

4.3.1 GROUNDWATER TREATABILITY STUDIES

THE FEASIBILITY STUDY ANALYSIS INDICATED A LACK OF PERFORMANCE DATA FOR THE TREATMENT ALTERNATIVES WITH RESPECT TO CHEMICAL AGENT DEGRADATION PRODUCTS SUCH AS THIODIGLYCOL, 1,4-DITHIANE, AND EXPLOSIVES. THEREFORE, A SERIES OF TREATABILITY STUDIES WERE CONDUCTED TO EVALUATE THE ABILITY OF EACH TREATMENT ALTERNATIVE TO TREAT OLD O-FIELD GROUNDWATER, AND TO COMPARE THE EFFECTIVENESS OF EACH TREATMENT ALTERNATIVE IN SATISFYING TREATMENT ARARS. BENCH-SCALE TREATABILITY STUDIES WERE CONDUCTED FOR TREATMENT ALTERNATIVES T-3 THROUGH T-5. TREATMENT ALTERNATIVE T-6 WAS NOT TESTED BECAUSE LITERATURE STUDIES INDICATED THAT ACTIVATED SLUDGE FOLLOWED BY CARBON ADSORPTION (ALTERNATIVE T-5) AND PACT (ALTERNATIVE T-6) PROVIDE COMPARABLE TREATMENT RESULTS (REFER TO TABLE 9).

PILOT-SCALE TESTS, FOR THOSE ALTERNATIVES DETERMINED TO BE EFFECTIVE IN TREATING OLD O-FIELD GROUNDWATER BASED ON BENCH-SCALE TESTING, WERE THEN CONDUCTED AT OLD O-FIELD USING GROUNDWATER EXTRACTED DURING THE AQUIFER PUMPING TESTS TO EVALUATE AND COMPARE THE EFFECTIVENESS AND IMPLEMENTABILITY OF THE ALTERNATIVES UNDER ACTUAL FIELD CONDITIONS.

AS NOTED, WATER QUALITY STANDARDS OR CRITERIA (AS WELL AS TOXICITY DATA FOR SOME COMPOUNDS) ARE LACKING FOR SEVERAL KEY CHEMICALS OF CONCERN AT OLD O-FIELD, ESPECIALLY DEGRADATION PRODUCTS OF CHEMICAL AGENTS AND OTHER MILITARY-SPECIFIC COMPOUNDS. IN ADDITION, TOXICITY INFORMATION FOR COMPLEX MIXTURES OF ORGANIC CONTAMINANTS AND METALS, SUCH AS THOSE PRESENT AT OLD O-FIELD, IS GENERALLY INCOMPLETE; THEREFORE, POSSIBLE SYNERGISTIC EFFECTS OR OTHER INTERACTIONS CAN BE VERY DIFFICULT TO PREDICT. BASED ON THESE FACTORS, IT WAS CONSIDERED IMPORTANT TO DEVELOP DIRECT METHODS FOR MEASURING TREATMENT SYSTEM PERFORMANCE AS A FUNCTION OF OVERALL REDUCTION OF TOXICITY, RATHER THAN EVALUATING SYSTEM PERFORMANCE SOLELY ON THE BASIS OF CHEMICAL REMOVAL EFFICIENCY. TO MEET THIS GOAL, SAMPLES OF UNTREATED GROUNDWATER AND UNIT PROCESS EFFLUENTS FROM THE VARIOUS

OPERATIONS (E.G., CHEMICAL PRECIPITATION, UV-OXIDATION, AIR STRIPPING, CARBON ADSORPTION, ACTIVATED SLUDGE) WERE COLLECTED AND USED IN A SERIES OF ACUTE BIOTOXICITY STUDIES INVOLVING SEVERAL AQUATIC ORGANISMS THAT WOULD TYPICALLY BE FOUND IN ENVIRONMENTS SIMILAR TO WATSON CREEK (MYSID SHRIMP, DAPHNIDS, FATHEAD AND SHEEPSHEAD MINNOWS). ACUTE BIOTOXICITY STUDIES WERE PERFORMED AS PART OF BOTH THE BENCH-SCALE AND PILOT-SCALE TREATABILITY TESTING PROGRAMS. THE RESULTS OF THESE TESTS ARE SUMMARIZED IN THE PARAGRAPHS BELOW ALONG WITH TREATMENT SYSTEM PERFORMANCE DATA. CHRONIC BIOTOXICITY STUDIES WERE NOT PERFORMED DURING TREATABILITY TESTING BECAUSE TREATED EFFLUENT WAS NOT GENERATED OVER THE TIME FRAME REQUIRED FOR THE STUDIES. CHRONIC BIOTOXICITY STUDIES WILL BE PERFORMED DURING START-UP OF THE FULL-SCALE TREATMENT SYSTEM, AND AS PART OF A MONITORING PROGRAM DURING OPERATION. RESULTS OF CHRONIC STUDIES WILL BE PRESENTED IN THE FINAL ROD FOR OLD O-FIELD.

CHEMICAL PRECIPITATION.

CHEMICAL PRECIPITATION USING LIME TO RAISE THE PH OF THE GROUNDWATER TO 11.0 WAS DETERMINED TO PROVIDE THE BEST METALS REMOVAL BASED ON BENCH-SCALE TESTING RESULTS. TABLE 10 PRESENTS METALS REMOVAL DATA FROM THIS CHEMICAL PRECIPITATION BENCH-SCALE TEST. THE DATA DEMONSTRATE THAT CHEMICAL PRECIPITATION IS EFFECTIVE IN REDUCING METALS CONCENTRATIONS AND MEETING MCLS AND AWQCS WITH THE EXCEPTION OF IRON WHICH HAD A CONCENTRATION OF 701 UG/L AFTER PRECIPITATION COMPARED TO ITS SECONDARY MCL OF 300 UG/L. SECONDARY MCLS ARE ESTABLISHED FOR CONTAMINANTS THAT PRIMARILY AFFECT THE AESTHETIC QUALITY RELATING TO THE PUBLIC ACCEPTANCE OF DRINKING WATER AND ARE NOT HEALTH-BASED OR FEDERALLY ENFORCEABLE. CALCIUM CONTENT INCREASED SUBSTANTIALLY DUE TO THE ADDITION OF LIME. THE CHEMICAL PRECIPITATION PROCESS WAS FOUND TO ELIMINATE THE ACUTE TOXICITY TO FATHEAD MINNOWS AND DAPHNIDS EXHIBITED BY THE UNTREATED GROUNDWATER.

A CONTINUOUS FLOW, PILOT-SCALE CHEMICAL PRECIPITATION STUDY WAS PERFORMED OVER A FOUR-DAY PERIOD. THE PILOT-SCALE STUDY WAS OPERATED UNDER THE SAME PH CONDITIONS AS THE BENCH-SCALE STUDY. TABLE 11 PRESENTS METALS REMOVAL DATA FOR CHEMICAL PRECIPITATION FROM DAY 3 OF THE PILOT-SCALE TEST. THE DATA DEMONSTRATE THAT CHEMICAL PRECIPITATION IS EFFECTIVE IN REDUCING METALS CONCENTRATIONS AND SATISFYING MCL/AWQC CRITERIA WITH THE EXCEPTION OF IRON AND LEAD. IRON WAS PRESENT AT 442 UG/L FOLLOWING PRECIPITATION COMPARED TO ITS SECONDARY MCL OF 300 UG/L. LEAD WAS PRESENT AT 5.80 UG/L COMPARED TO A FRESHWATER CHRONIC AWQC OF 3.20 UG/L AND MARINE CHRONIC AWQC OF 5.6 UG/L. LEAD WAS, HOWEVER, REDUCED BELOW ITS MCL AND ACUTE AWQCS. PILOT-SCALE CHEMICAL PRECIPITATION WAS CONDUCTED WITHOUT THE BENEFIT OF FIELD DATA NECESSARY TO OPTIMIZE OPERATING PARAMETERS SUCH AS PH. IT IS POSSIBLE THAT SYSTEM PERFORMANCE COULD HAVE BEEN IMPROVED IF FIELD DATA WERE AVAILABLE TO MAKE FIELD ADJUSTMENTS. CALCIUM WAS ALSO FOUND TO INCREASE DUE TO LIME ADDITION. THE CALCIUM CAME FROM CALCIUM SULFATE SOLIDS PRODUCED DURING NEUTRALIZATION OF THE GROUNDWATER WITH SULFURIC ACID. THE CALCIUM LEVEL IN THE FINAL EFFLUENT CAN BE REDUCED BY FILTERING THE GROUNDWATER FOLLOWING NEUTRALIZATION WITH A MULTI-MEDIA FILTER. THE CHEMICAL PRECIPITATION PROCESS WAS FOUND TO ELIMINATE THE ACUTE TOXICITY TO FATHEAD MINNOWS, DAPHNIDS, SHEEPSHEAD MINNOWS, AND MYSID SHRIMP EXHIBITED BY THE UNTREATED GROUNDWATER.

AIR STRIPPING/CARBON ADSORPTION.

THE BENCH-SCALE AIR STRIPPING PROCESS CONSISTED OF AERATING METALS-PRETREATED GROUNDWATER IN SEALED 55-GALLON DRUMS USING COMPRESSED AIR AT 3 CFM. AERATION CONTINUED FOR 18 HOURS AFTER WHICH VOLATILE EMISSIONS MEASURED LESS THAN 1 PPM WITH AN HNU METER. THE AERATED GROUNDWATER WAS THEN SENT THROUGH THREE CONTINUOUS FLOW CARBON ADSORPTION COLUMNS ARRANGED IN SERIES OVER A PERIOD OF 10 DAYS. TABLE 12 PRESENTS ORGANICS REMOVAL DATA FROM THE AIR STRIPPING/CARBON ADSORPTION BENCH-SCALE TEST FOLLOWING CARBON COLUMN 3 ON THE FIRST DAY OF OPERATION. THE DATA DEMONSTRATE THAT AIR STRIPPING FOLLOWED BY CARBON ADSORPTION IS EFFECTIVE IN REDUCING VOLATILE ORGANIC CONTAMINANT CONCENTRATIONS AND SATISFYING MCL/AWQC CRITERIA FOR THESE COMPOUNDS WITH THE EXCEPTION OF CARBON TETRACHLORIDE AND TETRACHLOROETHYLENE. CARBON TETRACHLORIDE HAD A CONCENTRATION AFTER CARBON ADSORPTION OF 10 UG/L COMPARED TO ITS MCL OF 5 UG/L. THE TOTAL CONCENTRATION OF 1,1,2,2-TETRACHLOROETHANE AND TETRACHLOROETHYLENE WAS 48 UG/L AFTER CARBON ADSORPTION COMPARED TO THE MCL FOR TETRACHLOROETHYLENE OF 5 UG/L. ORGANOSULFUR, ORGANOPHOSPHORUS, AND EXPLOSIVE COMPOUNDS WERE ALL REDUCED TO BELOW DETECTION LIMITS AFTER CARBON ADSORPTION. FINAL EFFLUENT WATER EXHIBITED NO ACUTE TOXICITY TO FATHEAD MINNOWS AND DAPHNIDS.

THE PILOT-SCALE AIR STRIPPING/CARBON ADSORPTION TREATMENT SYSTEM WAS A CONTINUOUS-FLOW PROCESS WHICH OPERATED OVER A TWO-DAY PERIOD. METALS-PRETREATED GROUNDWATER INITIALLY WAS PUMPED TO A 16-INCH DIAMETER AIR STRIPPER CONTAINING 20 FEET OF PACKING. THE AIR-TO-WATER RATIO IN THE STRIPPER WAS MAINTAINED AT 120:1. EMISSIONS

FROM THE AIR STRIPPER WERE DIRECTED TO A VAPOR-PHASE CARBON ADSORPTION UNIT. FOLLOWING AIR STRIPPING, THE GROUNDWATER WAS PUMPED TO FIVE CARBON ADSORPTION UNITS INSTALLED IN SERIES. THIS ARRANGEMENT ALLOWED COLLECTION OF CONTAMINANT BREAKTHROUGH DATA WHILE MAINTAINING FINAL EFFLUENT QUALITY. TABLE 13 PRESENTS ORGANICS REMOVAL DATA FOR THE AIR STRIPPING/CARBON ADSORPTION PILOT-SCALE TEST. CONCENTRATIONS LISTED FOR GROUNDWATER FOLLOWING CHEMICAL PRECIPITATION ARE FROM AN AIR STRIPPING INFLUENT SAMPLE COLLECTED FOLLOWING TREATMENT OF 12,600 GALLONS OF GROUNDWATER. THIS WAS THE FINAL INFLUENT SAMPLE COLLECTED. CONCENTRATIONS LISTED FOR GROUNDWATER FOLLOWING AIR STRIPPING AND EACH OF THE FIVE CARBON UNITS ARE FROM SAMPLES COLLECTED DURING THE FINAL SAMPLING EVENT AFTER TREATMENT OF 18,500 GALLONS OF GROUNDWATER. THE DATA DEMONSTRATE THAT AIR STRIPPING FOLLOWED BY CARBON ADSORPTION IS EFFECTIVE IN REDUCING VOC CONCENTRATIONS AND SATISFYING MCL/AWQC CRITERIA FOR THESE COMPOUNDS. THE CARBON ADSORPTION DATA INDICATES THAT, EVEN AFTER TREATMENT OF 18,500 GALLONS, VOC CONCENTRATIONS WERE REDUCED TO LEVELS BELOW THE PRACTICAL QUANTITATION LIMITS. CARBON ADSORPTION ALSO TREATED ORGANOSULFUR AND EXPLOSIVE COMPOUNDS TO BELOW DETECTION LIMITS. CONTAMINANT BREAKTHROUGH WAS OBSERVED IN THE FIRST TWO UNITS FOR THIODIGLYCOL AND IN THE FIRST UNIT FOR 1,4-OXATHIANE. DATA ON COMPOUNDS EXHIBITING BREAKTHROUGH ARE NECESSARY TO PROPERLY SIZE A FULLSCALE CARBON ADSORPTION SYSTEM. WITH THIS DATA, A FULL SCALE SYSTEM CAN BE DESIGNED SUCH THAT RESIDUAL VOCs AS WELL AS THIODIGLYCOL AND 1,4-OXATHIANE WILL BE TREATED TO NEAR OR BELOW DETECTION LIMITS ALONG WITH THE REMAINING ORGANIC CONTAMINANTS. THE EFFLUENT FROM THE FINAL CARBON ADSORPTION UNIT WAS NOT ACUTELY TOXIC TO FATHEAD MINNOWS, DAPHNIDS, SHEEPSHEAD MINNOWS, AND MYSID SHRIMP.

ULTRAVIOLET-OXIDATION.

THE BENCH-SCALE UV-OXIDATION STUDY WAS CONDUCTED ON METALS-PRETREATED GROUNDWATER IN AN ENCLOSED REACTOR OPERATING IN A RECYCLE BATCH MODE. A HIGH INTENSITY UV-LAMP WAS USED IN THE REACTOR ALONG WITH HYDROGEN PEROXIDE AS AN OXIDANT. A HYDROGEN PEROXIDE CONCENTRATION OF 25 MG/L WITH 8 MINUTES OF EXPOSURE TIME, DETERMINED TO BE NECESSARY FOR COMPLETE CONTAMINANT DESTRUCTION BASED ON PRELIMINARY TESTING, WAS UTILIZED. IN ADDITION, A CONTROL TEST, USING AN EXTERNAL HEAT SOURCE RATHER THAN UV LIGHT, WAS CONDUCTED TO DETERMINE WHETHER VOC REDUCTION COULD BE ATTRIBUTED TO VAPORIZATION FROM TEMPERATURE INCREASES CAUSED BY THE UV LIGHT RATHER THAN DESTRUCTION. TABLE 14 PRESENTS ORGANICS REMOVAL DATA FROM THE UV-OXIDATION BENCH-SCALE STUDY. THE DATA DEMONSTRATE THAT UV-OXIDATION IS EFFECTIVE IN REDUCING VOLATILE ORGANIC COMPOUND CONCENTRATIONS AND SATISFYING MCL/AWQC CRITERIA FOR THESE COMPOUNDS. 1,4-DITHIANE, 1,4-OXATHIANE, AND RDX WERE ALL REDUCED TO BELOW DETECTION LIMITS FOLLOWING UV-OXIDATION. THIODIGLYCOL WAS REDUCED TO 13.2 UG/L AND 1,3,5-TRINITROBENZENE WAS REDUCED TO 1.12 UG/L. THERE ARE NO MCL OR AWQC CRITERIA FOR THESE COMPOUNDS. THE UV-OXIDATION CONTROL SAMPLE SHOWS SOME REDUCTION OF VOCs DUE TO VOLATILIZATION; HOWEVER, THE MAJORITY OF VOC REMOVAL CAN BE ATTRIBUTED TO DESTRUCTION IN THE UV-OXIDATION PROCESS RATHER THAN THROUGH VOLATILIZATION. FINAL EFFLUENT WATER WAS NOT ACUTELY TOXIC TO FATHEAD MINNOWS AND DAPHNIDS.

METALS-PRETREATED GROUNDWATER WAS TREATED IN A SEMI-CONTINUOUS MODE IN A PILOT-SCALE ULTRAVIOLET-OXIDATION UNIT WHICH HOUSED FOUR HIGH INTENSITY 15-KW LAMPS MOUNTED IN SERIES. HYDROGEN PEROXIDE WAS USED AS THE OXIDANT. AFTER EXITING THE REACTOR, TREATED WATER PASSED THROUGH A MANGANESE-GREENSAND FILTER TO REDUCE RESIDUAL HYDROGEN PEROXIDE TO LESS THAN 1 PPM. TABLE 15 PRESENTS ORGANICS REMOVAL DATA FOR THE ULTRAVIOLET-OXIDATION PILOT-SCALE TEST. CONCENTRATIONS LISTED FOR GROUNDWATER FOLLOWING CHEMICAL PRECIPITATION ARE FROM DAY 2 OF OPERATION WHICH REPRESENT THE FEED WATER TO THE UV-OXIDATION TESTS. THE UV-OXIDATION RESULTS ARE FOR THE TEST RUN WHICH YIELDED THE BEST OXIDATION RATES (I.E., AN INITIAL HYDROGEN PEROXIDE DOSAGE OF 60 MG/L). THE DATA DEMONSTRATE THAT UV-OXIDATION IS EFFECTIVE IN REDUCING VOC CONCENTRATIONS AND SATISFYING MCL/AWQC CRITERIA. ORGANOSULFUR AND EXPLOSIVE COMPOUNDS WERE ALSO REDUCED TO LEVELS BELOW DETECTION LIMITS. EXCEPT FOR 1,3,5-TRINITROBENZENE WHICH WAS DETECTED AT 0.528 UG/L. THERE ARE NO MCLS OR AWQCS FOR THESE COMPOUNDS. THE FINAL UV-OXIDATION EFFLUENT EXHIBITED NO ACUTE TOXICITY TO FATHEAD MINNOWS, DAPHNIDS, SHEEPSHEAD MINNOWS, AND MYSID SHRIMP.

ACTIVATED SLUDGE/CARBON ADSORPTION.

BENCH-SCALE ACTIVATED SLUDGE TESTING CONSISTED OF AN AERATION REACTOR AND A SETTLING COLUMN. EFFLUENT FROM THE REACTOR ENTERED THE SETTLING COLUMN WHERE THE SLUDGE WAS RECYCLED BACK TO THE AERATION BASIN. THE SYSTEM WAS DESIGNED TO OPERATE AS A CONTINUOUS-FLOW PROCESS ALLOWING A 12-HOUR RETENTION TIME. THE SLUDGE WAS ACCLIMATED OVER A 4-DAY PERIOD WITH A MIXTURE OF GROUNDWATER AND SEWAGE. AFTER ACCLIMATION, THE SYSTEM OPERATED 24 HOURS PER DAY FOR 22 CONSECUTIVE DAYS. IN ADDITION, A CONTROL TEST, WHEREBY METALS-PRETREATED GROUNDWATER WAS SENT THROUGH THE PROCESS WITHOUT SLUDGE UNDER OTHERWISE NORMAL OPERATING CONDITIONS FOR 12

HOURS, WAS CONDUCTED TO DETERMINE WHETHER VOC REDUCTION IN THE GROUNDWATER COULD BE ATTRIBUTED TO INADVERTENT AIR STRIPPING DURING AERATION IN THE REACTOR RATHER THAN BIODEGRADATION.

TABLE 16 PRESENTS ORGANICS REMOVAL DATA FOR ACTIVATED SLUDGE COLLECTED AFTER 22 DAYS OF OPERATION. THE DATA DEMONSTRATE THAT ACTIVATED SLUDGE IS EFFECTIVE IN REDUCING VOC CONTAMINANT CONCENTRATIONS AND SATISFYING MCL/AWQC CRITERIA WITH THE EXCEPTION OF 1,2-DICHLOROETHANE, TETRACHLOROETHYLENE, TRICHLOROETHYLENE, AND BENZENE, WHICH WERE PRESENT AT 8.3, 19, 7.3, AND 7.6 UG/L, RESPECTIVELY (THE MCL FOR EACH OF THESE COMPOUNDS IS 5 UG/L). THIODIGLYCOL, 1,4-OXATHIANE, AND HMX WERE ALL REDUCED BELOW DETECTION LIMITS FOLLOWING ACTIVATED SLUDGE TREATMENT. 1,4-DITHIANE WAS REDUCED TO 36 UG/L, AND DIMETHYL METHYLPHOSPHONATE (DMMP) WAS REDUCED TO 10.2 UG/L. THERE ARE NO MCL OR AWQC CRITERIA FOR THESE COMPOUNDS. ALTHOUGH THE DATA ARE NOT PRESENTED, CARBON ADSORPTION FOLLOWING ACTIVATED SLUDGE WAS EFFECTIVE IN REDUCING THE REMAINING ORGANIC CONTAMINANTS. THE FINAL EFFLUENT FOLLOWING CARBON ADSORPTION WAS NOT ACUTELY TOXIC TO FATHEAD MINNOWS AND DAPHNIDS. ALTHOUGH THE ACTIVATED SLUDGE RESULTS PRESENTED IN TABLE 16 SEEM SOMEWHAT PROMISING, THE CONTROL TEST RESULTS DEMONSTRATE THAT MUCH OF THE VOC REDUCTION CAN BE ATTRIBUTED TO VOLATILIZATION RATHER THAN BIODEGRADATION. IN ADDITION, TOTAL ORGANIC CARBON (TOC) DATA COLLECTED DURING THE ACTIVATED SLUDGE BENCH-SCALE TEST (TABLE 17) INDICATE THAT THE SYSTEM DID NOT REACH STEADY STATE WITHIN THE 22 DAYS OF OPERATION (I.E., THE EFFLUENT TOC CONTENT IS HIGHLY VARIABLE). THIS INABILITY TO REACH STEADY STATE HAS BEEN ATTRIBUTED TO THE LEVEL OF ORGANIC CONTAMINATION IN THE GROUNDWATER WHICH IS TOO LOW TO MAINTAIN A HEALTHY BIOMASS AS DEMONSTRATED BY THE SLUDGE CULTURE WHICH WAS SLOWLY DYING OFF. SINCE THE ACTIVATED SLUDGE SYSTEM PROVED TO BE UNSTABLE GIVEN THE ORGANIC CONTAMINANT LEVELS IN THE OLD O-FIELD GROUNDWATER AND MUCH OF THE VOC REDUCTION WAS DUE TO VOLATILIZATION RATHER THAN BIODEGRADATION, ACTIVATED SLUDGE TREATMENT WAS DETERMINED TO BE IN APPROPRIATE FOR APPLICATION AT OLD O-FIELD AND NO PILOT-SCALE TESTING WAS PERFORMED. ACTIVATED SLUDGE FOLLOWED BY CARBON ADSORPTION OFFERS NO BENEFITS OVER THE OTHER TREATMENT ALTERNATIVES.

4.3.2 GROUNDWATER TREATMENT ALTERNATIVES EVALUATION

GROUNDWATER TREATMENT ALTERNATIVES ARE EVALUATED BELOW WITH RESPECT TO THE NINE CRITERIA SPECIFIED IN SECTION 4.1. A SUMMARY OF THE EVALUATION RESULTS IS PRESENTED IN TABLE 18.

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT.

ALL OF THE ACTIVE GROUNDWATER TREATMENT ALTERNATIVES (T-3 THROUGH T-6) WOULD BE DESIGNED TO REDUCE THE CHEMICAL CONCENTRATIONS IN THE GROUNDWATER TO BELOW MCL/AWQC CRITERIA, THUS ADEQUATELY PROTECTING HUMAN HEALTH AND THE ENVIRONMENT. GROUNDWATER TREATMENT ALTERNATIVES, WHEN COUPLED WITH A COMPLEMENTARY GROUNDWATER EXTRACTION/DISCHARGE ALTERNATIVE, WILL PROVIDE ACTIVE REMEDIATION OF THE CONTAMINATED GROUNDWATER, THUS REDUCING FUTURE RISK ASSOCIATED WITH THE SITE. BECAUSE THE "NO ACTION" AND "MINIMAL ACTION" ALTERNATIVES ARE NOT PROTECTIVE OF HUMAN HEALTH AND THE ENVIRONMENT, THEY ARE NOT CONSIDERED FURTHER IN THIS ANALYSIS AS OPTIONS FOR THIS SITE.

COMPLIANCE WITH ARARS.

ALL OF THE ACTIVE TREATMENT ALTERNATIVES SHALL MEET THEIR RESPECTIVE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS OF FEDERAL AND STATE ENVIRONMENTAL LAWS AND WOULD BE OPERATED IN ACCORDANCE WITH ALL FEDERAL AND MARYLAND TREATMENT FACILITY REQUIREMENTS. TREATMENT SYSTEMS SHALL BE DESIGNED TO REDUCE CHEMICAL CONCENTRATIONS IN THE GROUNDWATER TO BELOW MCL/AWQC CRITERIA FOR EACH CHEMICAL PRESENT FOR WHICH SUCH STANDARDS EXIST. TARGET LEVELS SPECIFIED FOR GROUNDWATER TREATMENT, WHETHER THEY ARE STATUTORY OR RISK-BASED, ARE EXPECTED TO BE SUFFICIENTLY LOW SUCH THAT RE-INJECTION AND/OR SURFACE WATER DISCHARGE REQUIREMENTS ARE ALSO SATISFIED. ALL ACTIVE GROUNDWATER TREATMENT ALTERNATIVES ARE EXPECTED TO COMPLY WITH ALL ARARS RELATED TO THE GROUNDWATER MEDIA BY TREATING EXTRACTED GROUNDWATER TO ACCEPTABLE LEVELS FOR DISCHARGE TO THE GUNPOWDER RIVER.

AIR STRIPPING IS A CROSS-MEDIA TREATMENT TECHNIQUE; THAT IS, IT SOLVES THE GROUNDWATER PROBLEM BY TRANSFERRING CONTAMINATION TO THE ATMOSPHERE. AIR EMISSIONS REGULATIONS ESTABLISHED BY THE STATE OF MARYLAND AND THE EPA WILL REQUIRE CONTROL OF VOLATILE ORGANIC EMISSIONS FROM THE AIR STRIPPER. ADDITION OF EITHER A VAPOR-PHASE CARBON ADSORPTION UNIT OR A CATALYTIC CONVERTER SHOULD BE ADEQUATE TO MEET ACTION-SPECIFIC ARARS.

AS DEMONSTRATED DURING BENCH-SCALE TREATABILITY TESTING, BIOLOGICAL TREATMENT TECHNIQUES (ALTERNATIVES T-5

AND T-6) ARE LIKELY TO REMOVE VOLATILE ORGANIC CONTAMINANTS THROUGH AIR STRIPPING RATHER THAN BIODEGRADATION. CONTROL OF AIR EMISSIONS TO COMPLY WITH AIR EMISSIONS REGULATIONS ESTABLISHED BY THE STATE OF MARYLAND AND THE EPA WOULD BE MORE DIFFICULT TO IMPLEMENT THAN FOR AN AIR STRIPPER.

ALL OF THE ACTIVE GROUNDWATER TREATMENT ALTERNATIVES GENERATE A PRECIPITANT SLUDGE. THE PRECIPITANT SLUDGE WILL REQUIRE TOXICITY CHARACTERISTIC LEACHING PROCEDURE (TCLP) ANALYSIS PRIOR TO DISPOSAL AT A RCRA PERMITTED FACILITY. FAILURE TO PASS THE TCLP TEST MAY RESULT IN THE NEED FOR SLUDGE STABILIZATION OR SOLIDIFICATION IN ORDER TO MEET RCRA ARARS. INITIAL ANALYSES OF THE PRECIPITANT SLUDGES FROM BENCH-SCALE AND PILOT-SCALE TREATABILITY TESTING INDICATE THAT THE SLUDGE IS NON-HAZARDOUS. HOWEVER, CHANGES IN THE CONTAMINANT MAKE-UP OF THE GROUNDWATER COULD IMPACT THE COMPOSITION OF THE PRECIPITANT SLUDGE SO THAT IT IS HAZARDOUS.

ALTERNATIVES T-3 AND T-5 ALSO GENERATE SPENT CARBON. TYPICALLY, ACTIVATED CARBON VENDORS SUPPLY THE CARBON AS WELL AS HANDLE REMOVAL AND REGENERATION OF SPENT CARBON. INITIAL ANALYSES OF THE SPENT CARBON FROM BENCH-SCALE AND PILOT-SCALE TREATABILITY TESTING INDICATE THAT THE SPENT CARBON IS NON-HAZARDOUS.

THE UV-OXIDATION PROCESS USED IN ALTERNATIVE T-4 GENERATES NO SLUDGE OR AIR EMISSIONS.

ALTERNATIVES T-5 AND T-6 ALSO GENERATE BIOLOGICAL TREATMENT SLUDGE. THE BIOLOGICAL SLUDGE WILL REQUIRE TCLP ANALYSIS PRIOR TO DISPOSAL AT A RCRA PERMITTED FACILITY. FAILURE TO PASS THE TCLP TEST MAY RESULT IN THE NEED FOR STABILIZATION OR SOLIDIFICATION IN ORDER TO MEET ARARS. INITIAL ANALYSES OF THE SPENT ACTIVATED SLUDGE FROM BENCH-SCALE TREATABILITY TESTING INDICATE THAT THE SLUDGE IS NON-HAZARDOUS, EXCEPT POSSIBLY FOR THE CHARACTERISTIC OF REACTIVITY.

LONG-TERM EFFECTIVENESS AND PERMANENCE.

ALL OF THE ACTIVE GROUNDWATER TREATMENT ALTERNATIVES UTILIZE PRECIPITATION FOR METALS REMOVAL. PRECIPITATION IS CONTROLLED BY THE SOLUBILITY OF THE INORGANIC SPECIES, WHICH IS IN TURN CONTROLLED BY THE PH OF THE GROUNDWATER. AT THE OPTIMUM PH RANGE FOR THE METALS PRESENT IN THE GROUNDWATER, IT IS EXPECTED THAT METALS AND INORGANIC CONTAMINANTS PRESENT IN THE GROUNDWATER AT OLD O-FIELD WILL BE EFFECTIVELY PRECIPITATED BASED ON THE GROUNDWATER TREATABILITY TESTING RESULTS DESCRIBED ABOVE.

ALTERNATIVE T-3 UTILIZES AIR STRIPPING IN COMBINATION WITH CARBON ADSORPTION TO REMOVE ORGANIC CONTAMINANTS FROM THE GROUNDWATER. AIR STRIPPING IS CONTROLLED BY THE VOLATILITY OF EACH INDIVIDUAL CHEMICAL AS MEASURED BY THE HENRY'S LAW CONSTANT, WHICH ACCOUNTS FOR THE COMPOUND'S SOLUBILITY AND VAPOR PRESSURE, AMONG OTHER PARAMETERS. AIR STRIPPING WORKS BEST FOR CONTAMINANTS WITH HIGH VOLATILITY AND LOW SOLUBILITY; THE HIGHER THE HENRY'S LAW CONSTANT, THE EASIER THE CHEMICAL IS REMOVED VIA AIR STRIPPING. AIR STRIPPING CAN ACHIEVE 90+ PERCENT REMOVAL EFFICIENCY FOR MANY ORGANIC CONTAMINANTS BASED ON THE GROUNDWATER TREATABILITY TESTING RESULTS DESCRIBED ABOVE. GENERALLY, A COMPOUND'S SOLUBILITY AND ABSORBABILITY ARE INVERSE (I.E., THE MORE SOLUBLE A COMPOUND IS, THE LESS IT ADSORBS TO ACTIVATED CARBON). THEORETICALLY, CARBON ADSORPTION IS CAPABLE OF REDUCING ORGANIC CONTAMINANTS TO NON-DETECTABLE LEVELS AS LONG AS ADEQUATE CARBON DEPTH, AND THEREFORE CONTACT TIME, IS AVAILABLE. AIR STRIPPERS AND ACTIVATED CARBON ADSORPTION ARE OFTEN USED IN CONJUNCTION AND COMPLEMENT EACH OTHER'S EFFECTIVENESS. MANY OF THE CHEMICALS IN OLD O-FIELD GROUNDWATER HAVING RELATIVELY SHORT ACTIVATED CARBON BREAKTHROUGH TIMES ARE VOLATILE AND MAY BE READILY REMOVED VIA AIR STRIPPING. CONTAMINANTS SUCH AS 1,1,2,2-TETRACHLOROETHANE, THIODIGLYCOL, AND 1,4-DITHIANE ARE NOT EFFECTIVELY REMOVED VIA AIR STRIPPING; HOWEVER, THESE CONTAMINANTS ARE EFFECTIVELY CAPTURED BY THE ACTIVATED CARBON UNIT AS DEMONSTRATED BY GROUNDWATER TREATABILITY TESTING.

ALTERNATIVE T-4 UTILIZES UV-OXIDATION TO DESTROY ORGANIC CONTAMINANTS.

TREATABILITY DATA INDICATE THAT UV-OXIDATION WILL DESTROY MOST, IF NOT ALL, OF THE ORGANIC GROUNDWATER CONTAMINANTS PRESENT AT OLD O-FIELD INCLUDING THIODIGLYCOL AND 1,4-DITHIANE. OXIDATION MAY TAKE LONGER OR REQUIRE GREATER DOSAGES FOR LOW MOLECULAR WEIGHT POLAR COMPOUNDS (E.G. CHLOROFORM) AND COMPLEX ORGANIC COMPOUNDS BUILT AROUND A BENZENE RING STRUCTURE (E.G., POLYNUCLEAR AROMATIC HYDROCARBONS). THESE COMPOUNDS, THEREFORE, ARE THE RATE LIMITING COMPOUNDS.

ALTERNATIVE T-5 UTILIZES BIOLOGICAL TREATMENT (E.G., ACTIVATED SLUDGE) AND CARBON ADSORPTION FOR DESTRUCTION/REMOVAL OF ORGANIC CONTAMINANTS FROM THE GROUNDWATER. ACTIVATED SLUDGE HAS BEEN APPLIED TO

NUMEROUS INDUSTRIAL WASTEWATERS CONTAINING A WIDE VARIETY OF ORGANIC COMPOUNDS. ADDITION OF ACTIVATED CARBON POLISHING UNITS GENERALLY IMPROVES THE OVERALL ORGANIC REMOVAL EFFICIENCY OF THE BIOLOGICAL TREATMENT SYSTEM. TREATABILITY DATA INDICATE THAT BIOLOGICAL TREATMENT IS NOT APPROPRIATE FOR OLD O-FIELD GROUNDWATER FOR TWO REASONS: 1) THE ORGANIC CONTAMINANT CONCENTRATIONS IN THE GROUNDWATER ARE TOO LOW TO MAINTAIN A HEALTHY BIOMASS, CREATING AN UNSTABLE SYSTEM AS DEMONSTRATED IN THE GROUNDWATER TREATABILITY TESTS; AND 2) VOLATILE ORGANIC COMPOUNDS ARE AIR STRIPPED FROM THE AERATION BASIN BEFORE THE MICROORGANISMS HAVE AN OPPORTUNITY TO BIODEGRADE THEM. IN ADDITION, BIOLOGICAL TREATMENT MAY PRESENT OPERATIONAL DIFFICULTIES SINCE THE SYSTEM IS SUSCEPTIBLE TO UPSET BY HIGHLY VARIABLE WASTE STREAMS AND/OR VARIABLE WATER FLOWRATES, BOTH OF WHICH ARE ANTICIPATED AT OLD O-FIELD.

THE EFFECTIVENESS OF THE PACT SYSTEM USED IN ALTERNATIVE T-6 TO DESTROY ORGANIC CONTAMINANTS IS COMPARABLE TO THAT OF THE ACTIVATED SLUDGE SYSTEM WITH ACTIVATED CARBON POLISHING UNITS USED IN ALTERNATIVE T-5; HOWEVER, PACT IS LESS SUSCEPTIBLE TO UPSET FROM VARIABLE FLOWRATES AND INFLUENT CONTAMINANT CONCENTRATIONS BECAUSE THE ACTIVATED CARBON IN THE PACT UNIT ACTS AS A BUFFER TO THE VARYING CONCENTRATIONS.

STRINGENT PERFORMANCE MONITORING OF THE TREATED EFFLUENT WILL BE REQUIRED OF ALL ALTERNATIVES THROUGHOUT THE LIFE OF THE OPERATION PRIOR TO DISCHARGE TO ENSURE GROUNDWATER TREATMENT GOALS ARE CONSISTENTLY MET. MONITORING WILL INCLUDE CHEMICAL ANALYSIS AND BIOTOXICITY TESTING.

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT.

ALL OF THE ACTIVE GROUNDWATER TREATMENT ALTERNATIVES REDUCE BOTH THE TOXICITY AND THE VOLUME OF CONTAMINANTS IN THE GROUNDWATER BY REMOVING THE CONTAMINANTS. THE MOBILITY OF THE CHEMICALS IN THE GROUNDWATER IS A FUNCTION OF THE GROUNDWATER EXTRACTION/DISCHARGE ALTERNATIVE SELECTED.

CHEMICAL PRECIPITATION, UTILIZED FOR METALS REMOVAL IN ALL OF THE ACTIVE GROUNDWATER TREATMENT ALTERNATIVES, REMOVES THE METAL AND OTHER INORGANIC CONTAMINANTS FROM THE GROUNDWATER REDUCING ITS TOXICITY. THIS IS ACCOMPLISHED BY CONCENTRATING THE CONTAMINANTS INTO A METAL SLUDGE.

ALTERNATIVE T-3 INCORPORATES AIR STRIPPING AND CARBON ADSORPTION FOR ORGANICS REMOVAL. AIR STRIPPING, A CROSS-MEDIA TREATMENT TECHNIQUE, SOLVES THE GROUNDWATER PROBLEM BY TRANSFERRING CONTAMINATION TO THE ATMOSPHERE. AIR EMISSIONS FROM THE AIR STRIPPER LIKELY WILL REQUIRE CONTROL IN THE FORM OF: 1) A CATALYTIC CONVERTER THAT DESTROYS THE ORGANIC CONTAMINANTS BUT REQUIRES SCRUBBING OF ACID GASES THEREBY GENERATING A WASTEWATER; OR 2) A VAPOR-PHASE CARBON ADSORPTION UNIT THAT CAPTURES THE ORGANIC CONTAMINANTS WHICH ARE LATER DESTROYED THROUGH OFF-SITE REGENERATION. LIQUID-PHASE CARBON ADSORPTION ALSO CAPTURES ORGANIC CONTAMINANTS; THESE CONTAMINANTS ARE LATER DESTROYED THROUGH OFF-SITE REGENERATION OR ARE DISPOSED AS WASTE MATERIALS. THEREFORE, ALTERNATIVE T-3 REDUCES THE TOXICITY OF THE GROUNDWATER BY TRANSFERRING THE CONTAMINANTS TO OTHER MEDIA THAT REQUIRE OFF-SITE DESTRUCTION OR DISPOSAL.

ALTERNATIVE T-4 INCORPORATES UV-OXIDATION FOR ORGANICS REMOVAL. UV-OXIDATION COMPLETELY DESTROYS ORGANIC CONTAMINANTS IN THE GROUNDWATER ON SITE THEREBY REDUCING THE TOXICITY OF THE GROUNDWATER WHILE GENERATING NO TREATMENT RESIDUALS.

ALTERNATIVE T-5 INCORPORATES ACTIVATED SLUDGE TREATMENT AND CARBON ADSORPTION FOR ORGANICS REMOVAL. WHEN OPERATING EFFECTIVELY, AS SHOWN BY TREATABILITY TESTING TO NOT BE THE CASE FOR OLD O-FIELD GROUNDWATER, ACTIVATED SLUDGE TREATMENT COMPLETELY DESTROYS ORGANIC CONTAMINANTS ON SITE. HOWEVER, ACTIVATED SLUDGE SYSTEMS TYPICALLY TRANSFER ORGANIC CONTAMINANTS TO THE AIR THROUGH INADVERTENT AIR STRIPPING IN THE AERATION BASIN AS DEMONSTRATED BY GROUNDWATER TREATABILITY TESTING. SPENT ACTIVATED SLUDGE, WHICH SHOULD NOT CONTAIN ORGANIC COMPOUNDS IF THE TREATMENT IS EFFECTIVE, IS GENERATED. THE LIQUID-PHASE CARBON ADSORPTION UNIT CAPTURES ANY REMAINING ORGANIC CONTAMINANTS; THESE CONTAMINANTS ARE LATER DESTROYED THROUGH OFF-SITE REGENERATION OR ARE DISPOSED AS WASTE MATERIALS. THEREFORE, ALTERNATIVE T-5 REDUCES THE TOXICITY OF THE GROUNDWATER BY CONTAMINANT DESTRUCTION AND BY TRANSFERRING THE CONTAMINANTS TO THE AIR OR OTHER MEDIA THAT REQUIRE OFF-SITE DESTRUCTION OR DISPOSAL. ALTERNATIVE T-6 IS SIMILAR TO ALTERNATIVE T-5.

SHORT-TERM EFFECTIVENESS.

THE SHORT-TERM EFFECTIVENESS IS SIMILAR FOR ALL THE ACTIVE GROUNDWATER TREATMENT ALTERNATIVES. CONSTRUCTION

OF THE TREATMENT FACILITY AND SUPPORT STRUCTURES WILL BE COMPLETED WITH STANDARD CONSTRUCTION EQUIPMENT, BUT WILL ENTAIL ADDITIONAL RISKS TO WORKERS BEYOND THAT RISK INHERENT WITH CONSTRUCTION PROJECTS BECAUSE OF THE POTENTIAL FOR ENCOUNTERING UNEXPLODED ORDNANCE (UXO).

STRINGENT PERFORMANCE MONITORING OF THE TREATED EFFLUENT WILL BE REQUIRED DURING TREATMENT PLANT START-UP OPERATIONS TO ENSURE THAT GROUNDWATER TREATMENT GOALS ARE MET.

IMPLEMENTABILITY.

COMPONENT TECHNOLOGIES OF ALTERNATIVES T-3 AND T-5 ARE WELL-PROVEN, COMMERCIALY AVAILABLE, AND COMMONLY USED IN WATER AND WASTEWATER TREATMENT PROCESSES.

ALTHOUGH UV-OXIDATION (ALTERNATIVE T-4) HAS BEEN USED AT SEVERAL CERCLA AND INDUSTRIAL SITES, IT IS STILL CONSIDERED AN INNOVATIVE TECHNOLOGY. THE EQUIPMENT IS AVAILABLE THROUGH ONLY A FEW COMPANIES; THE UNITS MAY BE AVAILABLE 6 TO 12 WEEKS AFTER RECEIPT OF A PURCHASE ORDER.

THE PACT SYSTEM USED IN ALTERNATIVE T-6 IS PATENTED AND ONLY AVAILABLE THROUGH ONE VENDOR. IT HAS BEEN UTILIZED AT A NUMBER OF INDUSTRIAL AND HAZARDOUS WASTE SITES.

COST.

THE RATE OF GROUNDWATER EXTRACTION, AND THEREFORE THE FLOW TO THE TREATMENT SYSTEM, VARIES WITH THE SELECTION OF AN EXTRACTION/DISCHARGE ALTERNATIVE. EXTRACTION RATES FOR THE GROUNDWATER EXTRACTION/ DISCHARGE ALTERNATIVES CONSIDERED RANGE FROM 20.6 GPM (ALTERNATIVE E-4) TO 46.1 GPM (ALTERNATIVE E-5). FOR COSTING PURPOSES, A FLOWRATE OF 25 TO 30 GPM WAS USED FOR TREATMENT ALTERNATIVES.

ALTERNATIVE T-3 HAS A PRESENT WORTH OF \$9,392,000 AND ALTERNATIVE T-4 HAS A PRESENT WORTH OF \$7,357,000 FOR A 30-YEAR PERIOD AT A 5 PERCENT DISCOUNT RATE. THESE ESTIMATES ARE BASED ON EQUIPMENT CHARACTERISTICS DETERMINED FOLLOWING TREATABILITY TESTING. ALTERNATIVES T-5 AND T-6 HAVE PRESENT WORTH OF \$6,449,000 AND \$5,582,000, RESPECTIVELY, BASED ON INITIAL ESTIMATES PRIOR TO PERFORMANCE OF

THE TREATABILITY STUDIES.

THE COSTS ASSOCIATED WITH ALTERNATIVES T-5 AND T-6 WERE NOT UPDATED SINCE BENCH-SCALE TREATABILITY TESTING SHOWED BIOLOGICAL TREATMENT TO BE INAPPROPRIATE FOR OLD O-FIELD GROUNDWATER.

STATE ACCEPTANCE.

THE STATE OF MARYLAND CONCURS WITH THE SELECTED TREATMENT ALTERNATIVE INDICATED IN THE DECLARATION AND SECTION.5.0.

COMMUNITY ACCEPTANCE.

AS MENTIONED IN SECTION 1.4, THE PUBLIC WAS INVITED TO REVIEW THE ADMINISTRATIVE RECORD, ATTEND A PUBLIC MEETING, AND SUBMIT COMMENTS ON ALL TREATMENT ALTERNATIVES UNDER CONSIDERATION. THE RESPONSIVENESS SUMMARY PROVIDED IN APPENDIX A GIVES A THOROUGH REVIEW OF PUBLIC COMMENTS AS WELL AS ARMY AND EPA RESPONSES. COMMUNITY ACCEPTANCE IS ASSESSED IN DETAIL IN THE RESPONSIVENESS SUMMARY.

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5.0 SELECTED REMEDIAL ALTERNATIVE

THIS SECTION IDENTIFIES AND SUMMARIZES THE SELECTED INTERIM ACTION IN RESPONSE TO OU ONE FOR OLD O-FIELD. EXTRACTION/DISCHARGE AND TREATMENT COMPONENTS OF THE REMEDY ARE DESCRIBED ALONG WITH AN OVERVIEW OF THE RATIONALE FOR SELECTION. A DISCUSSION OF HOW THE SELECTED REMEDY SATISFIES THE STATUTORY REQUIREMENTS OF SECTION 121 OF CERCLA IS ALSO INCLUDED.

5.1 ALTERNATIVE DESCRIPTION

THE PREFERRED ALTERNATIVE FOR CONTAINING THE CONTAMINATED GROUNDWATER AT OLD O-FIELD IS DOWNGRADIENT EXTRACTION OF THE CONTAMINATED GROUNDWATER PLUME, AS DESCRIBED IN ALTERNATIVE E-I, FOLLOWED BY ON-SITE TREATMENT UTILIZING CHEMICAL PRECIPITATION FOLLOWED BY ULTRAVIOLET-OXIDATION TO REMOVE THE FULL RANGE OF INORGANIC AND ORGANIC CONTAMINANTS, AND DISCHARGE TO THE GUNPOWDER RIVER, AS DESCRIBED IN ALTERNATIVE T-4. THIS REMEDIAL APPROACH IS BELIEVED TO PROVIDE THE BEST BALANCE OF TRADE-OFFS WITH RESPECT TO THE EVALUATION CRITERIA. THE TOTAL ESTIMATED CAPITAL COST OF THE REMEDY IS \$1,881,000, AND THE TOTAL ESTIMATED OPERATION AND MAINTENANCE COSTS ARE \$466,650 PER YEAR. THE TOTAL ESTIMATED PRESENT WORTH IS \$9,120,000 BASED ON A 30-YEAR PERIOD AND A 5 PERCENT DISCOUNT RATE. THE REMEDY IS EXPECTED TO REQUIRE 18 TO 36 MONTHS TO IMPLEMENT.

NEW GROUNDWATER EXTRACTION WELLS WILL BE LOCATED IN AREAS OF HIGHEST GROUNDWATER CONTAMINATION DOWNGRADIENT OF THE SOURCE. THE EXTRACTION SYSTEM WILL BE DESIGNED TO CAPTURE CONTAMINATION EMANATING FROM THE LANDFILL TO THE MAXIMUM POSSIBLE EXTENT. THE NUMBER AND SPECIFIC DESIGN OF THE EXTRACTION WELLS, WILL BE SPECIFIED BY TESTING NEWLY INSTALLED WELLS DURING AN EARLY PERIOD OF THE DESIGN/CONSTRUCTION PHASE OF THE REMEDIATION EFFORT. THESE TESTS ALSO WILL BE USED TO DETERMINE THE CAPTURE ZONE, AQUIFER YIELD, AND OPTIMAL PUMPING RATE FOR EACH WELL AND THE COMBINED SYSTEM. AT LEAST THREE PIEZOMETERS SHALL BE UTILIZED IN THE VICINITY OF EACH EXTRACTION WELL TO MONITOR HORIZONTAL AND VERTICAL HYDRAULIC GRADIENTS AND CONTAMINANT DISTRIBUTIONS IN GROUNDWATER. THE USEABILITY OF EXISTING WELLS AS MONITORING POINTS WILL BE DETERMINED DURING THE DESIGN PHASE.

COLLECTED GROUNDWATER WILL BE TREATED BY CHEMICAL PRECIPITATION FOLLOWED BY ULTRAVIOLET-OXIDATION PRIOR TO DISCHARGE TO THE GUNPOWDER RIVER. THE PROCESSES LIKELY WILL BE CONTINUOUS-FLOW OPERATED AT THE GROUNDWATER EXTRACTION FLOWRATE. CHEMICAL PRECIPITATION WILL GENERATE A SLUDGE WHICH WILL BE EVALUATED FOR HAZARDOUS WASTE CHARACTERISTICS AND TRANSPORTED AND DISPOSED IN ACCORDANCE WITH APPLICABLE FEDERAL AND STATE REGULATIONS. BASED ON TREATABILITY TEST RESULTS AND 24 HOUR/DAY OPERATION, APPROXIMATELY 43,000 GALLONS/YEAR OF SLUDGE WILL BE GENERATED. THE ULTRAVIOLET-OXIDATION PROCESS WILL NOT GENERATE ANY TREATMENT RESIDUALS. THE EXTRACTED GROUNDWATER WILL BE TREATED TO ATTAIN CHEMICAL-SPECIFIC ARARS WHICH SHALL INCLUDE AMBIENT WATER QUALITY CRITERIA PROMULGATED UNDER THE CLEAN WATER ACT AND MAXIMUM CONTAMINANT LEVELS PROMULGATED UNDER THE SAFE DRINKING WATER ACT. TREATABILITY TEST RESULTS CONFIRM THESE ARARS ARE ATTAINABLE WITH THIS TREATMENT SEQUENCE. TREATABILITY TESTING ALSO DEMONSTRATED THAT COMPOUNDS NOT REGULATED BY THESE ARARS, SUCH AS CHEMICAL WARFARE AGENT DEGRADATION PRODUCTS, CAN BE TREATED TO LESS THAN INSTRUMENT DETECTION LEVELS USING THE SELECTED TREATMENT APPROACH. STRINGENT PERFORMANCE MONITORING OF THE TREATED EFFLUENT, INCLUDING CHEMICAL SAMPLING AND BIOTOXICITY TESTING THROUGHOUT THE LIFE OF THE OPERATION, WILL BE PERFORMED PRIOR TO DISCHARGE TO ENSURE ARARS ARE SATISFIED CONSISTENTLY.

5.2 COMPLIANCE WITH STATUTORY REQUIREMENTS

5.2.1 PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

THE SELECTED INTERIM ACTION ALTERNATIVE PROTECTS HUMAN HEALTH AND THE ENVIRONMENT FROM THE RISKS ASSOCIATED WITH GROUNDWATER CONTAMINATION FROM OLD O-FIELD AND ITS MIGRATION INTO INTERCONNECTING SURFACE WATERS. THIS IS ACCOMPLISHED BY CONTAINING THE CONTAMINATED GROUNDWATER NEAR THE SOURCE SO THAT IT DOES NOT DISCHARGE TO WATSON CREEK. FURTHERMORE, THE EXTRACTED GROUNDWATER WILL BE TREATED TO ACCEPTABLE LEVELS PRIOR TO DISCHARGE TO THE GUNPOWDER RIVER. HUMAN POPULATIONS WILL BE PROTECTED FROM DIRECT CONTACT AND FOOD-CHAIN EXPOSURES ASSOCIATED WITH CONTAMINANT MIGRATION FROM THE GROUNDWATER INTO WATSON CREEK AND, ULTIMATELY, THE GUNPOWDER RIVER. AQUATIC LIFE IN WATSON CREEK AND THE GUNPOWDER RIVER, AND TERRESTRIAL WILDLIFE FEEDING ON AQUATIC LIFE, WILL ALSO BE PROTECTED FROM RISKS ASSOCIATED WITH GROUNDWATER CONTAMINANT MIGRATION FROM OLD O-FIELD.

5.2.2 COMPLIANCE WITH ARARS

THE SELECTED INTERIM ACTION ALTERNATIVE WILL COMPLY WITH CHEMICAL-SPECIFIC ARARS APPLICABLE TO GROUNDWATER REMEDIATION AS DEMONSTRATED BY TREATABILITY TESTING. ARARS CONSIDERED FOR OLD O-FIELD GROUNDWATER TREATMENT INCLUDE AMBIENT WATER QUALITY CRITERIA PROMULGATED UNDER THE CLEAN WATER ACT AND MAXIMUM CONTAMINANT LEVELS PROMULGATED UNDER THE SAFE DRINKING WATER ACT. IN ADDITION, CHEMICAL PRECIPITATION SLUDGE WILL BE ANALYZED FOR RCRA HAZARDOUS WASTE CHARACTERISTICS TO ENSURE THAT RCRA LAND DISPOSAL RESTRICTIONS ARE SATISFIED.

5.2.3 COST EFFECTIVENESS

THE SELECTED INTERIM ACTION HAS BEEN DETERMINED TO PROVIDE THE BEST OVERALL EFFECTIVENESS PROPORTIONAL TO ITS COSTS OF ALL THE ALTERNATIVES CONSIDERED. DOWNGRAIDENT EXTRACTION WITH DISCHARGE TO SURFACE WATER IS THE LOWEST COST EXTRACTION/DISCHARGE ALTERNATIVE IDENTIFIED; HOWEVER, IT IS EFFECTIVE IN CAPTURING THE CONTAMINATED GROUNDWATER PLUME FROM OLD O-FIELD. AS DEMONSTRATED THROUGH TREATABILITY TESTING, ALTERNATIVES T-3 AND T-4 ARE THE ONLY GROUNDWATER TREATMENT ALTERNATIVES EFFECTIVE IN REMOVING INORGANIC AND ORGANIC CONTAMINANTS BELOW TARGET CLEANUP AND ACUTE TOXICITY LEVELS WHILE MAINTAINING A STABLE MODE OF OPERATION. OF THESE, CHEMICAL PRECIPITATION FOLLOWED BY ULTRAVIOLET-OXIDATION (ALTERNATIVE T-4) IS THE LOWER COST ALTERNATIVE. ALTERNATIVE T-4 HAS THE ADDED BENEFIT OVER ALTERNATIVE T-3 OF DESTROYING ORGANIC CONTAMINANTS IN THE GROUNDWATER OR SITE WITHOUT GENERATING TREATMENT RESIDUALS.

5.2.4 UTILIZATION OF PERMANENT SOLUTIONS AND ALTERNATIVE TREATMENT TECHNOLOGIES (OR RESOURCE RECOVERY TECHNOLOGIES) TO THE MAXIMUM EXTENT PRACTICABLE

THIS INTERIM ACTION IS NOT DESIGNED OR EXPECTED TO BE FINAL, BUT THE SELECTED REMEDY REPRESENTS THE BEST BALANCE OF TRADE-OFFS AMONG ALTERNATIVES WITH RESPECT TO PERTINENT CRITERIA, GIVEN THE LIMITED SCOPE OF THE ACTION.

5.2.5 PREFERENCE FOR TREATMENT AS A PRINCIPAL ELEMENT

BY TREATING THE CONTAMINATED GROUNDWATER BY CHEMICAL PRECIPITATION FOLLOWED BY ULTRAVIOLET-OXIDATION, THE SELECTED REMEDIAL ACTION ADDRESSES ONE OF THE PRINCIPAL THREATS POSED BY THE SITE THROUGH THE USE OF TREATMENT. THEREFORE, ALTHOUGH THIS ACTION IS NOT A FINAL REMEDY, THE STATUTORY PREFERENCE OF TREATMENT AS A PRINCIPAL ELEMENT IS SATISFIED.

5.3 PERFORMANCE MONITORING PROGRAM

A MONITORING PROGRAM SHALL BE DEVELOPED TO EVALUATE THE EXTENT TO WHICH THE GROUNDWATER EXTRACTION AND TREATMENT COMPONENTS OF THE INTERIM RESPONSE ACTION PERFORM IN COMPLIANCE WITH APPLICABLE CHEMICAL CRITERIA FOR CHEMICALS PRESENT IN THE EXTRACTED GROUNDWATER. THESE CHEMICAL SPECIFIC CRITERIA SHALL BE DEVELOPED IN ACCORDANCE WITH THE RESULTS OF THE PERFORMANCE MONITORING PROGRAM, THE AMBIENT WATER QUALITY CRITERIA, AND SUBSTANTIVE REQUIREMENTS OF THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM.

5.3.1 GROUNDWATER CONTAINMENT MONITORING

A GROUNDWATER MONITORING PLAN SHALL BE DEVELOPED AND IMPLEMENTED DURING THE INTERIM RESPONSE ACTION TO ENSURE THAT HYDRAULIC CONTROL OF THE PLUME OF CONTAMINATION EMANATING FROM OLD O-FIELD TOWARDS WATSON CREEK IS MAINTAINED. SPECIFICALLY, AN INWARD AND UPWARD GRADIENT WITHIN THE PLUME MUST EXIST TO MITIGATE THE DISCHARGE OF CONTAMINATED GROUNDWATER TO WATSON CREEK. INFORMATION NECESSARY FOR THIS DETERMINATION INCLUDES:

- * HORIZONTAL AND VERTICAL GRADIENTS IN THE GROUNDWATER BETWEEN OLD O-FIELD AND WATSON CREEK;
- * HORIZONTAL AND VERTICAL CONTAMINANT CONCENTRATION GRADIENTS IN GROUNDWATER BETWEEN OLD O-FIELD AND WATSON CREEK;
- * CHANGES IN CONTAMINANT CONCENTRATION OR DISTRIBUTION OVER TIME;
- * EFFECTS IN TIDAL INFLUENCE ON THE PLUME CAPTURE ZONE; AND
- * EFFECTS OF ANY MODIFICATIONS TO THE ORIGINAL INTERIM RESPONSE ACTION.

TO PROVIDE THIS INFORMATION, THE GROUNDWATER CONTAINMENT PERFORMANCE MONITORING PLAN SHALL INCLUDE, AT A MINIMUM, THE FOLLOWING: LOCATIONS OF NEW OR EXISTING MONITORING WELLS FOR WATER QUALITY SAMPLING; FREQUENCY OF WATER QUALITY SAMPLING; ANALYTICAL PARAMETERS (FOCUSING ON CHEMICALS OF CONCERN) AND ANALYTICAL PROCEDURES TO BE EMPLOYED; FIELD SAMPLING METHODS; SPECIFICATION OF WATER LEVEL MONITORING LOCATIONS, METHODS AND FREQUENCIES USING NEW OR EXISTING WELLS; AND METHODS FOR CAPTURE ZONE ANALYSIS.

5.3.2. EFFLUENT MONITORING PROGRAM

A MONITORING PLAN FOR THE EFFLUENT FROM THE TREATMENT PLANT SHALL BE DEVELOPED AND IMPLEMENTED DURING THE INTERIM RESPONSE ACTION TO ENSURE THAT CONTROL OF THE EFFLUENT IS MAINTAINED PRIOR TO DISCHARGE. A MONITORING PROGRAM SHALL BE DEVELOPED DURING THE DESIGN PHASE THAT PROVIDES PERIODIC AND/OR CONTINUOUS INFORMATION ON THE FOLLOWING PARAMETERS:

- * CHEMICAL CONSTITUENCY OF THE TREATMENT PLANT EFFLUENT; AND
- * ACUTE AND CHRONIC TOXICITY OF THE EFFLUENT.

TO PROVIDE THIS INFORMATION, THE EFFLUENT MONITORING PROGRAM SHALL INCLUDE, AT A MINIMUM, THE FOLLOWING: ANALYSIS OF 24-HOUR COMPOSITE SAMPLES AT A FREQUENCY OF TWICE A MONTH FOR TOTAL SUSPENDED SOLID, TOTAL ARSENIC OR METALS OF CONCERN, VOLATILE ORGANIC COMPOUNDS, AND OTHER CHEMICALS OF CONCERN; CONTINUOUS MONITORING OF PH AND CONTROL WITHIN THE LIMITS OF 6 AND 9; ACUTE TOXICITY TESTING PERFORMED ON A QUARTERLY BASIS FOR A PERIOD OF TWO YEARS. ACCORDING TO ESTABLISHED EPA PROTOCOLS; AND SHORT-TERM CHRONIC TESTING PERFORMED DURING THE THIRD AND FOURTH QUARTERS OF EACH YEAR FOR A PERIOD OF TWO YEARS, ACCORDING TO ESTABLISHED EPA PROTOCOLS.

5.4 SIGNIFICANT CHANGES FROM THE PROPOSED PLAN

THE PROPOSED PLAN FOR OU ONE AT OLD O-FIELD WAS RELEASED FOR PUBLIC COMMENT IN JULY 1991. THE PROPOSED PLAN IDENTIFIED ALTERNATIVE E-1, DOWNGRADEMENT EXTRACTION WITH DISCHARGE TO THE GUNPOWDER RIVER, COMBINED WITH ALTERNATIVE T-4, CHEMICAL PRECIPITATION FOLLOWED BY ULTRAVIOLET-OXIDATION TREATMENT OF CONTAMINATED GROUNDWATER, AS THE PREFERRED INTERIM RESPONSE ACTION. THE ARMY AND THE EPA REVIEWED ALL WRITTEN AND VERBAL COMMENTS SUBMITTED DURING THE PUBLIC COMMENT PERIOD. UPON REVIEW OF THESE COMMENTS, IT WAS DETERMINED THAT NO SIGNIFICANT CHANGES TO THE INTERIM ACTION, AS IT WAS ORIGINALLY IDENTIFIED IN THE PROPOSED PLAN, WERE NECESSARY.

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TABLE 10
CHEMICAL PRECIPITATION
BENCH-SCALE TREATABILITY DATA (UG/L)

PARAMETER-A	UNTREATED WATER-B	FOLLOWING CHEMICAL PRECIPITATION-C
ALUMINUM	254.00	46.00 U
ARSENIC	100.00	33.20
BARIUM	137.00 B	21.50 B
CALCIUM	26,400.00	56,900.00
COBALT	15.90 B	6.00 U
IRON	48,500.00	701.00
MAGNESIUM	21,400.00	9,050.00
MANGANESE	1,290.00	10.10 B
NICKEL	29.10 B	20.00 U
POTASSIUM	3,180.00 B	1,930.00 B
SELENIUM	15.00 U	3.90 B
SODIUM	20,100.00	14,800.00
VANADIUM	9.50 B	5.00 U
ZINC	538.00	15.80 B

A - ONLY INCLUDES COMPOUNDS DETECTED IN GROUNDWATER SAMPLES. DOES NOT
INCLUDE COMPOUNDS ANALYZED FOR AND NOT DETECTED.

B - BASED ON TREATABILITY TRAILER SAMPLES.

C - BASED ON LIME JAR TEST SAMPLES.

U - UNDETECTED AT THE LISTED DETECTION LIMIT.

B - REPORTED VALUE IS LESS THAN THE CONTRACT REQUIRED DETECTION LIMIT
(CRDL) AND GREATER THAN THE INSTRUMENT DETECTION LIMIT (IDL).

TABLE 11
CHEMICAL PRECIPITATION
PILOT-SCALE TREATABILITY DATA (UG/L)

PARAMETER-A	UNTREATED WATER-B	FOLLOWING CHEMICAL PRECIPITATION-B
ARSENIC	4.5 B	4.00 U
BARIUM	226.00	223.00
CALCIUM	35,100.00	151,000.00
COPPER	24.90 B	9.00 U
IRON	83,500.00	442.00
LEAD	136.00	5.80
MAGNESIUM	16,500.00	4,950.00 B
MANGANESE	1,690.00	12.20 B
POTASSIUM	1,100.00 U	1,360.00 B
SODIUM	15,600.00	17,900.00
VANADIUM	13.60 B	8.00 U
ZINC	125.00	27.70

A - ONLY INCLUDES COMPOUNDS DETECTED IN GROUNDWATER SAMPLES. DOES NOT
INCLUDE COMPOUNDS ANALYZED FOR AND NOT DETECTED.

B - BASED ON DAY 3 SAMPLES.

U - UNDETECTED AT THE LISTED DETECTION LIMIT.

B - REPORTED VALUE IS LESS THAN THE CONTRACT REQUIRED DETECTION LIMIT
(CRDL) AND GREATER THAN THE INSTRUMENT DETECTION LIMIT (IDL).